THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every other month
JANUARY, MARCH, MAY, JULY, SEPTEMBER, NOVEMBER

Subscription 5/- per annum, or 1/- per copy, post free, payable through any Agricultural Officer or to the Government Printer, P.O. Box 128, Nairobi, to whom all business communications should be addressed.

Editorial correspondence should be addressed to the Editor, Amani, via Tanga, Tanganyika Territory. Matter submitted for publication should preferably be sent through the local member of the Editorial Board.

EDITORIAL NOTES

AGRICULTURAL RESEARCH CONFERENCE.

From the 24th to the 28th February an East African agricultural conference, convened by the instruction of the Governors' Conference, met at the Amani Research Station. Four representatives each of the Departments of Agriculture of Kenya, Uganda and Tanganyika, including the respective Directors, attended, as well as the Director of the Amani Station, who presided, and two of his senior officers. The Secretary of the Governors' Conference was also present. Representatives of Zanzibar and Northern Rhodesia were prevented from attending by circumstances arising at the last moment. The Conference considered an agenda of 26 items, with reference to which 66 memoranda had been previously circulated. A report will be issued from Nairobi in the series "Technical Conferences of the East African Dependencies" by the Secretariat of the Governors' Conference. Selected groups of the memoranda will be edited for publication in the *East African Agricultural Journal.*

THE LATE MR. A. H. RITCHIE.

On the assembling of the Conference, the Chairman referred with deep regret to the death of Mr. A. H. Ritchie, Entomologist to the Tanganyika Department of Agriculture, who died on Lake Victoria on his way to attend the Conference. He said there were few men with so good a claim as Ritchie had to be called a practical entomologist. He was not satisfied to publish his conclusions; he spared no pains to see that their application was efficient. He had, moreover, an

intimate and remarkably exact knowledge of tropical agriculture. His death caused a serious loss to the Colonial Agricultural Service and to East Africa.

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COFFEE PROBLEMS.

An interesting discussion took place at the Conference on the subject of the factors influencing quality in coffee. A communication from Mr. Wolfe (Kenya) advocated an investigation of the nutrition of the tree in relation to liquoring quality. The author expressed the view that while liquoring quality was not definable in scientific terms, it was definable comparatively; over a wide range of samples the percentage of error would be small. The last-mentioned opinion was received with general dissent by the Conference members. Conclusions drawn from four years' experience in forwarding about 230 East African samples for estimation in London through Amani and the Imperial Institute were quoted. Calculations based on the results of submitting control samples showed that to detect an average difference of 25 per cent about 12 identical portions would need to be submitted, and for a difference of 12½ per cent, 50 such portions. In the few instances where the test of prices could be applied, there actually appeared an inverse relation between price and the estimated quality, due apparently to the greater influence of size and appearance. The Conference agreed that no progress was possible in the investigation of the factors affecting liquoring quality until a more reliable standard of quality was available, and that a chemical standard, as now sought bv Dr. Case, would be by far the most satisfactory.

Another question considered was that of the precautions necessary to be taken in connection with the marketing in Nairobi of coffee from Uganda, Bukoba, and the Congo, to avoid the risk of spread of berry borer to the Kenya plantations. At present, regulations are in force requiring coffee to be dried to a certain standard, based on investigations by Mr. Hargreaves, of the Uganda Department. The Coffee Board of Kenya submitted that free movement would have all-round advantages, and asked for consideration of the grounds which appeared to exist, justifying the relaxation of the restrictions. Representatives of Uganda and Tanganyika disclaimed interest in the question, as they were able to market all their coffee without the intervention of Nairobi. The opinions expressed by entomologists, including those of the Kenya Department, showed agreement in the belief that berry borer was not likely to be a pest at the altitudes at which coffee was grown in Kenya, and that moreover it was probably indigenous to that country. The Conference regarded the matter as a local one only, and left it to be dealt with, in the light of the discussion, by the parties concerned.

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NEW CROPS FOR EAST AFRICA.

Cinchona.—Much interest was shown in several prospective crops and their possibilities. The Chairman summarized the situation with regard to Cinchona. The Secretary of State had accepted the recent conclusion of his advisory committee that synthetic drugs were not likely, in the circumstances at present prevailing, to be sold cheaply enough to replace quinine. There were two alternative but not incompatible possibilities in East Africa. One was the production of Cinchona bark as an export commodity like any other, and one for which there was at present an urgent British demand. The other was to establish the local manufacture of Totaquina, a standard

compound of the various alkaloids in the bark, with the object of cheapening the treatment of malaria in the country. There were several localities in which the conditions for growing Cinchona seemed eminently favourable, although only Usambara had been adequately proved. Many attempts had been made, only as it appeared to be checked at the outset for lack of the special knowledge and skill required in the nursery stage. Central nurseries, from which plants could be distributed, offered the readiest means of meeting the difficulty. As the outcome of the discussion it was recommended that trials should be extended to apparently suitable localities, and that departments of agriculture should consider the establishment of central nurseries.

Tung Oil.—Reports were received from the five continental dependencies regarding trials of *Aleurites* sp. The evidence strongly favoured *A. montana* in comparison with *A. Fordii*. In Uganda neither gave much promise; in Kenya both grew, but *A. Fordii* was disappointing and *A. montana* more promising. In Tanganyika, with one local exception, *Fordii* had failed, while *montana* was doing well where it was tried. The reports from Nyasaland and Northern Rhodesia wholly favoured *montana*. The exception noted is at Uvinza, in Central Tanganyika, where 50 acres of *Fordii*, generously treated at planting, were thriving well. There are indications that this species requires to be treated on orchard lines. A factor that has to be taken into account when considering *montana* is the large proportion of male or nearly male trees.

Ramie.—There was considerable discussion of the prospects of ramie production, revived by the interest now taken in the crop by certain British firms. It was agreed that planting must be entered upon with caution. Ramie is a most exhausting crop, and if careful attention is not given to the maintenance of soil fertility production soon ceases to be profitable. Tanganyika policy was stated to be the encouragement of ramie as a side line to sisal, in acreages adjusted to the amount of compost, made from sisal waste, available as manure.

NATIVE SETTLEMENT IN TANGANYIKA.

During a discussion of native crops, Mr. Wakefield (Acting Director of Agriculture) gave an exceedingly interesting account of efforts which are being made to deal with the danger of over-population and soil deterioration in the Lake Province of Tanganyika. The Department of Agriculture was working in conjunction with the Medical, Education and Veterinary Departments on the lines of the Nigerian mixed farming scheme. The basis was the stall-feeding of cattle, of which the Lake Province contained about three per head of the human population. It had been decided to aim at a 15-20-acre holding, planted with trees as windbreaks, and divided into fields for the production of economic and food crops in rotation. If the animals were tethered when grazing the carrying capacity of the land was unexpectedly high. All crop refuse was saved, but water difficulties stood in the way of compost-making.

After initial opposition, the response of the local Wasukuma had been wonderfully encouraging. The three original volunteers had swelled to over 200, and the demonstration at Ukiruguru had been so successful that the officer in charge of the station had recently been asked by the surrounding population to reallocate the whole of the tribal land in peasant holdings. Moreover, the physique of the original holders had markedly improved. From the first the policy had

been to make the smallholders self-supporting. The implements issued to them, starting with a wooden plough, native made at the cost of Sh. 5, they paid for.

The Tanganyika Government had agreed to hand over to the Department of Agriculture for development in small holdings large blocks of land, e.g. 40 square miles, recovered by tsetse clearing operations. Hitherto such newly won land had been quickly ruined by the inrush of free-ranging cattle.

It was clearly held, both by the Africans themselves and the Department, that a man should only be allowed to retain his land so long as he was in beneficial occupation of it. The tribes concerned had been told that they were expected to work out for themselves, through their councils, a policy to fit the new conditions.

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A WORD TO THE WISE.

Sir Francis Acland, M.P., in a letter to *The Times*, makes the following remarks, which we commend, certain of the approval of our readers, to our contributors:—

"I am sometimes asked to revise proofs for publication on a technical subject and marvel how the experts who do the writing acquire the language which they employ. The following example is, I think, worthy of record. It concerns the habits of a moth:—

"It would appear from what evidence is available that the act of oviposition is immediately stimulated by the crepuscular diminution in the intensity of illumination, and the rise in relative humidity as the diurnal temperature decreases."

"I believe that this merely means: 'Egg-laying seems to be stimulated by twilight and the dampness of evening.' "

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SPECIAL NOTE *re* NOS. 1, 2 AND 3 OF THE *Journal*.

It is proposed to publish in the next issue a list of subscribers who are desirous of obtaining copies of the first three issues of the Journal, now out of print.

Subscribers who wish to have their names included in this list are asked to inform the Government Printer, P.O. Box 128, Nairobi, not later than the 30th May, 1936, stating the particular number or numbers they require, giving full name and postal address.

The intention is, when the list is published, that anyone who may have spare copies of the first three numbers for disposal will communicate direct with any individual named in the list.

It should be clearly understood that the Government Printer cannot undertake the exchange or disposal of such copies.

Reviews

"MIXED FARMING IN EAST AFRICA" by G. R. Morrison. *East Africa*, London, 1935; 12/6d.

There is amongst the classics a little book of essays on English farming (*Talpa, or the Chronicles of a Clay Farm*) whose dedication states them to be "based on the hope and belief that agricultural thought may be candid and even 'speculative' yet husbandry not the less practical." Had the author of *Talpa* lived a hundred years later, he might well have been a congenial neighbour of Mr. Morrison's on a Rift Valley farm. They would have been stout advocates together for a bold use of modern knowledge in framing a farming programme to fit the times. The same "hope and belief", at any rate, animates this pioneer book on high-altitude tropical mixed farming; there is a touch of the same humorous and picturesque vigour in the presentation, and the reader derives something of the same pleasure from seeing a good case ably handled.

The scope of the book can be simply stated. The author's "East Africa" consists of well-watered land at moderate to high elevation, near a railway and a local market for produce, and from which the native African as a stockholder has been excluded. Given these conditions, the principles of intensive management are developed that should be followed by the small farmer who intends to settle on about 300 to 500 acres of land and run it himself. There is an admirable chapter on "the lessons of the past" which is a reasonable but none the less severe condemnation of speculative farming, of one-crop farming, of the growing of low-value commodities, and of the failure to consider the small farm as an enterprise differing not only in scale from the large one. The same subjects are handled constructively in the remainder of the book, with sufficient practical detail from the author's own fifteen years' experience to give his discussions point and reality, whilst preserving the character of the whole as an essay rather than a textbook. Particular matters on which he is emphatic are the use of paddocking and rotational grazing, the adoption of lines of production that will bring in a steady monthly cheque, tree-planting about the farm, whole-hearted loyalty to co-operation, and high feeding both of stock and of land. In such a critical discussion of internal farm policy as this is, politics external cannot of course escape being touched upon; but the necessary references are brief and are kept to their place.

Mr. Morrison's timely and soundly informed book on the subject that matters more than any other just now to farmers in the highland areas, and to those advising them, cannot fail to have a wide sale to its public. In his introduction, he admits that "anyone who attempts to write a book about farming stands to be shot at". Doubtless many will have their shot, but the position is strongly defended. If the reviewer must have his, it will be to suggest that the somewhat limited possibilities of local markets have not been faced quite frankly. Upon the disposal of perishable produce mixed farming stands or falls, and in an East Africa (outside Mr. Morrison's white enclave) so slenderly populated with bacon and butter eaters, who is to buy?

G.M.

Improvement in Native Bee-keeping in Uganda

By T. W. CHORLEY, *F.R.E.S., Laboratory Assistant, Entomological Section, Uganda.*

Wild bees are present in all parts of Uganda, but are especially common in the Western and Northern Provinces. In most districts there are a few people who keep bees, but they do this solely to obtain honey for their own use, and they make little or no attempt to collect and sell beeswax.

Wild honey-bees make their nests in hollow trees, termite hills, or in any protected cavity sufficiently large to enable them to build comb in which to rear their young. Natives, knowing this habit, have long made use of the bees for honey, employing several sorts of hives, the most common of which are the hollow log and the basket with a covering of cow dung. These hives are placed in trees and bees come during the swarming season and make their homes in them. The owner of the hive collects honey during the season of the honey-flow, and in order to take out the honeycomb he kills or drives away the bees by means of burning grass. In this manner honey and wax are obtained plentifully, but the wax is of little value because it is dirty and contains dead bees and other rubbish. Actually, the large quantities of wax which are now thrown away could be sold with good profit if properly prepared.

During the last three years propaganda has been carried out, with the aid of Agricultural and District Officers, to improve the present methods adopted by native beekeepers in several districts. Bees are kept solely for the production of honey in Kigezi, Ankole, Masaka, Buruli, Toro, and Bugerere. In all of these districts the beekeepers had no use for empty comb, simply throwing it away. Brood comb is eaten raw in Kigezi, Ankole, and Toro, as well as other districts where propaganda has not been commenced. Buruli and Bugerere beekeepers do not seem to have acquired the taste for bee larvæ, because brood comb is thrown away as well as dry comb. The practice of eating brood comb is to be discouraged, because it seriously interferes with the population of the hive; and it is doubtful if beekeepers would persist in eating it if they could be made to realize that worker bees live only eight weeks, and that to eat the brood seriously reduces the population of a hive and the amount of honey produced.

The brood comb is the comb in which the young bees are reared. It contains little honey, the cells being mostly occupied by young bees. This brood comb is of permanent value to the bees, which use it continually. There is very little wax in it, and the wax is of poor quality and fetches a low price. For these reasons and because the brood comb contains many young bees, the destruction of it should be discouraged.

The honeycomb is the place where the bees store the honey. The wax of this comb is bright yellow in colour and of good quality.

The new hive designed for the use of natives consists of two chambers, separated by a queen excluder, which keeps the queen in the brood chamber and prevents her laying eggs in the cells of the comb in the other chamber where the honey is stored. The beekeeper is thus able to remove honeycomb without damaging the brood comb and to obtain clean honey and wax.

How the Hives are Constructed.

Two kinds of hives can be made easily. One is made of the bark of trees, and the other is constructed from elephant grass, papyrus, or bamboo, made rainproof by plastering with cow dung.

For making a bark hive, a wild fig tree, or any other tree with tough bark which can be stripped in one piece and will retain its natural shape after drying, is the best to use. The tree should be between one foot six and two feet thick; not larger or smaller. The bark should first be cut vertically in a straight line three feet long, and then cut around the tree at each end of this line and stripped off in one piece. When laid on the ground the bark will recover its original shape and appear like a hollow log. Some tough flexible saplings or climbing plants should be collected and made into rings to fit tightly inside the bark to support it, the edges of the bark being sewn together with strong string. Four rings should suffice. These are fixed to the bark by making small holes in it and tying the rings in place with string. Each ring should be tied in three places. The part of the hive thus made is called the honey chamber. To make the brood chamber, another strip of bark, two feet long, should be obtained from a tree a little thinner than the first, and the edges of the bark should be sewn together in such a way that a cone is formed. The end of the brood chamber must be of the right size to fit inside the end of the honey chamber. Some small holes should be bored close to the end of the brood chamber and the queen excluder carefully tied over the end. A circular pad with a small hole in the middle (for the bees to enter the hive) should be fixed in the other end of the brood chamber, and another pad, without a hole, should be fitted in the end of the honey chamber. Cow dung can now be plastered over the pads to seal the ends, except for the small hole for the bees to enter; and any cracks or holes in the bark should be filled with dung, especially in that part of the brood chamber where the queen-excluder is fixed. The two parts of the hive should then be hung in the smoke of a fire for two weeks, to remove the smell of the dung, which the bees do not like. The end of the brood chamber with the queen-excluder must then be fitted into the end of the honey chamber and the joint sealed with cow dung. Finally, the hive should be smoked again for two or three days, and it will then be ready to fix in position.

The second kind of hive, made from dry elephant grass, *mtama* stalks (sorghum), papyrus, or bamboo, is of the same form. It is made in two parts—the brood chamber with the small hole at one end, and the queen-excluder at the other end which fits into the end of the longer honey chamber. Pieces of dry elephant grass or papyrus of the required length are bound very closely together by means of string or banana fibre, and fastened around rings made from tough saplings or from climbing plants. When the construction of the two chambers is completed the surfaces are plastered with cow dung to make the hive rainproof. Special care must be taken to seal that part of the brood chamber near the queen-excluder so that the queen cannot pass between the stems into the honey chamber. The smell of the cow dung must be removed in the manner already described. In order to prevent the queen from going into the honey chamber it is of great importance to ensure that the excluder completely covers the end of the brood chamber. Coffee tray wire, one-fifth of an inch mesh, is a cheap and efficient excluder, and a piece nine inches square is used for each hive.

PLACING OF HIVES.

The place chosen for the hives should be about a hundred yards from any building. As many as twenty to thirty hives can be kept in the same place, so long as they are spaced three or four feet apart. The entrances to the hives should face east, unless the prevailing wind is from the east, when they should face west. The ground around each hive must be kept free from grass and weeds, and any obstruction immediately in front of an entrance, such as a bush or tree, should be removed, because it would hinder the bees going in and out.

Before the hive is placed in position it must be covered with grass to protect the dung from rain and sun; for this purpose sword grass is very suitable. The grass should be arranged in a thick, even layer lengthwise over the hive and bound with banana fibre; the grass must extend well beyond the honey-chamber end of the hive, and must there be gathered together, tied, and cut off beyond the knot. The end with the entrance hole must not be covered. The grass must never be untied except for removal of the pad to take away honeycomb, because exposure to the weather will cause the dung to crack and make openings through which another swarm of bees might enter and cause trouble.

The hive is best supported on three forked poles, like those used to support the roof of a hut. The height of the poles should be such that the bee entrance end of the hive will be on a level with the shoulder and the other end level with the forehead. The poles for this purpose should be of the sort which termites do not readily attack, or these insects will eat away the supports and the hive will fall and be ruined. Where no suitable poles are obtainable, freshly cut wild fig may be used, because it will grow and escape damage; otherwise, the hive may be placed in the fork of a tree, preferably near shoulder height, to make it easy to remove the honey.

The poles should be regularly inspected, and any damaged by termites must be replaced immediately by fresh poles. It is a simple matter to replace a damaged pole. The hive should be supported temporarily, close to the pole to be removed, by two crossed sticks, with their ends in the ground, tied together firmly under the hive; the earth should be dug away from the base of the damaged pole, and the latter removed carefully to avoid damaging the hive. The new pole should then be placed in position, and stones and earth packed under the end of it to raise the fork until it just supports the hive; the earth should then be rammed firmly around the base of the pole.

In districts troubled by the honey-ratel, hives should be suspended by rope or a crook stick from branches of trees and at least nine feet from the ground (*see* Plate 1).

HOW TO OBTAIN SWARMS OF BEES.

If the hives are fixed in a suitable place, swarms of bees will come and enter them. It is well to have a few empty hives in the house, because they will be useful to hold swarms which may be found hanging on the trees. These swarms may easily be captured. Swarming bees cannot sting; they fill their stomachs with honey before swarming, and they are unable to bend their abdomens into the position necessary for them to sting. The branch to which the swarm is clinging is cut and very gently carried to an empty hive. Then the swarm is held near to the hive entrance hole and shaken vigorously. The bees then enter

the hive. If owing to some mischance the swarm flies into a tree, it should be caught again, but this rarely occurs, because the bees are usually very pleased to find a new home. When all the bees have entered, the hive is placed on the forked poles which should be ready for it. Hives of bees should not be moved when once they have been placed in position, because moving them causes many bees to be lost.

How to Take out the Honeycomb.

During the season the beekeeper can open the hive by carefully removing the pad which seals the back end of it. By opening the hive at the back in this way no damage is done to the young bees which are all in the brood chamber. The hive should be opened about a quarter of an hour after sunset; if the manipulation is done later, a lamp must not be used, because many bees will fly to it and be killed, whilst others, crawling about the ground, will climb up the operator's clothes and sting him. After the pad is removed some smoke should be blown from smouldering grass into the honey chamber to drive the bees towards the brood chamber. The honeycomb can then be cut out and placed in a large clean pot. After the comb has been taken out, the pad should be fixed in position.

How to Separate the Honey from the Wax.

Two large clean-mouthed pots are required. A piece of honeycomb is put in a hessian money-bag, and is squeezed by means of two sticks, whilst the bag is held by the mouth by a second person, until all the honey is pressed out into the pot. The wax which is left in the bag is put into another pot. This is best done at night when there are no bees flying.

General Information.

If there is an abundance of flowers there is no limit to the number of hives a beekeeper may have. Any wild nests of bees within two miles of the hives should be destroyed as soon as the hives are all occupied, because these wild bees will gather nectar which can be collected by the hive bees.

Hives must be placed in position just before the season for collecting the wax and honey. If, after a period of three months, no bees have entered a hive, this indicates that the hive has not been sufficiently well smoked; in these circumstances it should then be taken from the support, and after the grass has been removed the brood chamber should be separated from the honey chamber, and both parts smoked again for a few days. When this re-smoking is completed, the hive should be put together (care being taken to seal the joint well with cow dung), and, after drying in the sun, smoked for another two days to remove all smell of the dung. The hive should then be covered again with grass and placed in position before the next honey season. If bees still refuse to enter, a piece of burnt honeycomb forced into the brood chamber through the bee entrance will prove attractive to swarms; this must be done only at the time when wild hives are being worked for honey.

Honey or wax should not be taken from the hives out of season, because the bees themselves require the honey as food when there is little to be gathered. The seasons of honey flow vary in different localities, and beekeepers should find out when these seasons are; they are usually just after the end of the dry season and the beginning of the new rains.

Three gallons of honey and one pound four ounces of primrose-coloured wax have been obtained from a new hive in a

year. These figures are obtained in Lwashamaire, Ankole District, where the honey-ratel is not present. Lwashamaire is almost the only place in Ankole known to the writer where the honey-ratel does no damage to hives.

How to Render down Wax from Hives without Excluder.

There are two qualities of bees-wax—dark and light. These are obtained from different sorts of comb, and as the light wax sells for a higher price it is important to keep the different sorts of comb separate and to select them carefully when rendering down wax.

The different types of comb are as follows:—

(*a*) Comb containing brood.
(*b*) Very light yellow or white comb, with or without honey.
(*c*) Dark yellow or light brown comb, with or without honey.
(*d*) Black heavy comb, with or without honey.

Comb containing brood is useless for wax-extraction, and should be thrown away, but any light-coloured or brown comb surrounding the brood should be broken off and used for wax-extraction.

The heavy black comb is also useless for wax because it contains the pupa-skins of many generations of bees which have bred in it, and if an attempt is made to render down wax from it these skins will absorb nearly all the wax (about 95 per cent). If there is honey in it, the comb can be eaten or the honey can be squeezed out; if there is no honey this sort of comb can be used as bait to attract new swarms, by breaking off small pieces and putting them in the entrance of new hives.

The following articles are required for the extraction of wax from the comb:—

Three large earthenware cooking-pots (one of these is for containing the honey).
Two water-pots half full of clean water.
The bottom parts of two broken water-pots (basins are better, if available).
A small hessian bag like those used to hold money.
A gourd cut in half so that it can be used as a ladle.
Two straight sticks, from two to two-and-a-half feet long and not more than an inch or less than three-quarters of an inch in diameter. These should be cut some time before so they are not too flexible.

Two people are required to extract wax properly, so the beekeeper has to have a friend to help him with the work.

The hives should be worked the night before the wax is to be extracted, and during the following day the comb should be kept hidden away, so that bees foraging for honey will not find it. Selection of comb and wax-extraction should not be started before 6.30 p.m., so that foraging bees will have gone back to their hives. If work is started earlier, bees will be attracted by the smell of honey, and will seriously interfere with the work.

The first operation is the selection of the comb, the light yellow or white comb and dark yellow or light brown comb being kept in separate pots.

Extraction of Dark Wax.

Removal of Honey and Preparation of the Comb.—Any comb which does not contain honey should be put at once into one of the pots, but if there is honey in the comb the honey should be squeezed out first in the manner already described. The bag used for squeezing is then

turned inside out over one of the two cooking-pots containing water, and the crushed comb from which the honey has been removed is emptied into the pot, together with the comb with no honey in it which was set aside before.

First Boiling.—The pot containing the wax and water is then placed over a fire, which must be small, because a fierce fire would burn the wax. The pot is supported over the fire by three large stones. It must be put on to the stones very carefully, because pots of this kind are very fragile, and if it is cracked and breaks during the boiling of the wax the people doing the work are likely to be badly scalded. The water in the pot is allowed to boil until all the comb has melted and there is a yellow froth on top of the water in the middle of the pot and at the sides. While the pot is on the fire the water must be stirred all the time, as otherwise the wax at the sides of the pot will be burnt.

Straining.—When the yellow froth appears the wax is nearly ready for straining, and an empty wide-mouthed pot should be placed alongside the fire with its bottom in a hollow made in the ground to prevent it falling over. The hessian bag is next held with its mouth open over the empty pot by one person, while the second person skims the boiling wax off the top of the water with the gourd and pours it into the bag. Not more than two gourds of the wax should be put into the bag each time, because otherwise much of the wax is left in the bag while the latter is being squeezed.

The person holding the bag then closes the mouth of the bag and holds it tightly over the empty pot while the second squeezes the wax and water out of it with the two sticks (*see* Plate 3). He must not squeeze too hard at first, otherwise the hot water will squirt out of the bag and scald his arms. After he has squeezed the bag with the sticks a few times he should hold it tightly with the two sticks while the other man twists it so as to squeeze out the rest of the wax. After a few minutes nearly all the wax and water will have been squeezed out of the bag, which now contains only "slum-gum", composed of pupa-skins, dead bees, grass, pollen, and dirt. There is a little wax in the "slum-gum" so it should be put aside in another pot to be dealt with later on. It must not be put back into the pot which is on the fire, nor must it be put with comb which has not been rendered down; it must be kept quite separate.

The "Slum-gum".—When all the first lot of wax has been squeezed through the bag into the wax-pot, the "slum-gum" may be reboiled for about a quarter of an hour or more, and the wax squeezed out as in the case of the comb, but the "slum-gum" does not contain very much wax. When the bee-keeper is experienced in wax-extraction he will probably find that his "slum-gum" contains so little wax that reboiling it is not worth while, but while he is learning he will usually leave enough wax in the "slum-gum" to make it worth his while to extract it.

Second Boiling.—After all the wax has been extracted from the comb, the pot in which the comb was boiled should be washed clean and filled about a quarter full of water. The wax in the wax-pot should be squeezed with both hands so as to make it into small balls, which are placed in the pot in which the wax was boiled before, put on a very small fire, and allowed to simmer. When all the balls of wax have melted, the wax should be skimmed off the top of the water with the gourd and put into the bag, which must be held over a basin or the bottom half of a broken water-pot.

This time most of the wax will ooze out of the bag without squeezing, as there is no longer any rubbish (dead bees, pupa-skins, etc.) in it to prevent it coming out easily. It is only necessary to use the sticks to squeeze out the bag when nearly all the wax has gone into the basin or broken pot. If there is a lot of wax to be rendered down, several basins or broken pots will be necessary.

When the basin or half-pot is nearly full it must be removed to a safe place and left there until the following morning, when the wax will be found to have solidified. The wax is then removed from the basin or pot by cutting round the edges with a knife, and it will come out as a solid block. There will be a little dirt sticking to the bottom of the block, and this should be scraped off with a knife; the block of wax is then ready for sale.

The scrapings from the bottom of the block of wax should not be thrown away but should be added to the next lot of comb which the beekeeper renders down.

Extraction of Light Wax.

The light-coloured wax is obtained from the comb which has never had brood bred in it, the darkness of the brown or black comb being caused by the bees breeding in it, and the depth of colour depending on the number of generations of bees for which the comb has been used.

The process for the extraction of the light-coloured wax is nearly the same as for the dark wax, and the honey must be removed first. The only differences are that the boiling need not be continued so long; that the froth which indicates that the wax is ready to be skimmed off is paler-coloured; that since the wax contains practically no rubbish it is easier to squeeze through the bag and can be squeezed into the basin or half-pot at once; and that there is no need to put it through the bag twice like the dark-coloured wax.

Treatment of Mixed Wax and Honey.

Many tribes, especially the Bakiga and Banyankole, crush the white and yellow comb containing honey into small pieces and put them into an earthenware pot. This mixture is sometimes eaten after a few days.

If the honey is intended for mead-making, however, the mixture is kept in the pot for a month or two, and in this case the honey granulates and the pot seems to contain nothing but honey, because granulated honey and white wax are similar in appearance. The Bakiga and Banyankole believe that the wax is honey, but when they use the mixture to make mead, adding water to it, the wax separates out (because wax will not dissolve in water, though honey will) and is thrown away. They do not know that they are throwing away wax because it is mixed with the remains of the *mtama* which they have added.

The wax is not at all necessary for mead-making because it does not dissolve in water and does not ferment, but it is difficult for natives to believe this, the method of making mead having been used by them for many generations and handed down from father to son.

Only light yellow or white comb should be used for mead-making, and the honey and wax should be separated as has been explained, and only the honey used. By this method the beekeeper would get just as good mead as he does at present and would be able to sell the wax.

PESTS.

The natives in some districts are seriously handicapped by the honey-ratel which does a considerable amount of

damage to hives, frequently ruining fifteen or more in a night. This beast is nocturnal in habit, and travels a considerable distance in search of hives. It has been known to go fifteen miles in search of them; and to tear open eight or more hives by means of its strong claws, devouring a little of the brood and carrying the remainder to some convenient hiding-place, where it returns the following night and carries off the hidden comb to its lair. They are said to travel in pairs, and it is interesting to note that in only one Gombolola, of all the districts where beekeeping propaganda has been carried out, was this beast known to the natives and a skin obtained. This skin is believed to be the first obtained in Uganda. Everywhere else where hives are frequently damaged, the natives all say that the civet-cat and leopard are responsible. The writer thinks that this belief is due to the fact that whenever a hive is damaged the traces of huge claw-marks may be seen on the tree or poles on which the hive was placed before being damaged by the animal, and the natives, on seeing these marks the following day, assume that such large claw-marks can only be made by the leopard.

There are no serious bee diseases yet known in Uganda; but numerous insect pests exist. The wax moth, which is very common on account of the carelessness of native beekeepers, exists throughout the more important beekeeping districts. By leaving comb lying about, this pest is allowed to breed almost unchecked, but it does no serious damage to hives because a strong colony of bees are able to keep it in check, and only the weaker ones suffer. But comb that is not kept in airtight tins or boxes is ruined in a very short space of time by the wax moth larvæ, which riddle the comb with holes in their search for food, and line the comb with silken threads. There are two species of dipterous parasites responsible for the death of worker bees and occasionally drones. The female of a species of Tachinid fly, *Rondanioestrus apivorus* Vill, sits near the entrance of the hive and waits for foraging bees returning to the hive. When a bee is about to alight on the hive the fly darts at it and deposits a tiny larva on the abdomen or the thorax of the bee. This action is so swift that it is scarcely discernible with the naked eye; all that can be seen is the fly darting at the bee, grappling with it, and immediately flying back to its resting place to continue the same procedure until such time as all the larvæ are deposited. It is capable of parasitizing some two hundred bees, and the tiny larva, when deposited on the bee, burrows its way through the intersegmental membrane and feeds on the abdominal tissues. When the larva is fully fed it makes its way out of the live bee by forcing its way out of the anus; the bee in the meantime rushes wildly about and, after the larva has emerged, suddenly falls dead. Bees have been seen on many occasions rushing about with a distended abdomen, and in every case close observation has shown a larva attempting to force its way out of the anus; the larva alternatively appears and withdraws, until finally it completely emerges, and the bee dies soon afterwards. The larva crawls about and pupates in a few minutes, and changes from cream colour to dark brown. A minute parasite has been found attacking the pupæ of the tachinid fly, and has been submitted to the British Museum for naming. The adult tachinid parasitizes the incoming worker bees indiscriminately, and therefore many larvæ must be deposited on old bees which die before the larvæ have time to reach maturity. The pest is not serious, because worker bees only leave

the hive at five to six weeks old, and then forage for another three weeks, so that a very large number of these parasite larvæ must die when these old bees die. The parasitized bee is in no way hindered in its foraging activities until the larva is about to emerge in order to pupate.

The Conopid fly parasite, *Physocephala pubescens* Brun., attacks the adult bee, and three colonies of Italian bees bred up from imported queens were killed off by the ravages of this insect in Uganda. Judging from the field observations done by entomologists in America, another species of Conopidæ parasitize humble-bees by waiting for them on certain flowers in order to deposit an egg on the humble-bee. The egg adheres to the bee by means of a jelly-like fluid, and when the egg hatches the larva burrows into the abdomen in the same way as the Tachinid larva. Many hundreds of the Italian bees from the three colonies in Uganda were picked up dead and dying during the month of October in 1934. The dead bees were found to have pupæ and the live ones larvæ of *Physocephala pubescens* in the abdomen. From the American observations, it seems probable that the Uganda parasite has a similar life-history, except that the carpenter-bees take the place of humble-bees as hosts. The Italian bee, being larger and having a much longer tongue than the local bee, visited flowers that are only rarely visited by the latter, and was mistaken for some of the smaller species of carpenter-bees found in Uganda. With regard to the local bee, this parasite cannot be termed a pest.

Ants.—These are more serious as pests in some localities than in others. At the same time they are beneficial, as they would no doubt help to eliminate the possibility of disease spreading should disease be introduced in Uganda. Weak colonies abandon hives that ants attack in their search for honey and bee larvæ. Safari ants attack even the strongest of colonies at times, and do a great amount of damage by attacking adult bees, larvæ, pupæ and eggs. At times the queen is killed, and, all larvæ and eggs having been taken, the bees which have escaped are unable to produce another queen, and the whole colony perishes.

Bee-eaters.—During the swarming season bee-eaters are responsible for the deaths of many thousands of bees. These birds are immigrants, and are only to be found during the months when bees swarm in Uganda. They are to be seen in flocks of thirty to forty individuals, darting here and there, and making a noise like the sharp crack of a whip whenever they snap up a bee or other insect on the wing.

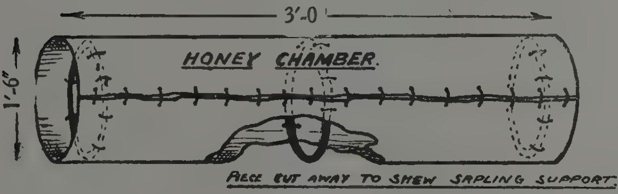
Value of Wax.

Beekeeping, from a native point of view, should prove a profitable pastime, because the amount of comb thrown away that could be made into wax is considerable, and the price of bees-wax very rarely fluctuates to any great extent and the wax fetches a high price. The native producer can rely on fifty cents a pound being paid for this wax, provided that he does not adulterate it with animal fats and keeps it reasonably clean. Samples of wax were submitted to H.M. African Dependencies Commissioner for valuation. Native-produced, dark wax was valued at £92 per ton net weight, packed in bags free, c.i.f. any main European ports, and pale wax, produced from the new type of hives having queen excluders, was valued at £97/10 per ton in February, 1934. These quotations were received from Messrs. Poth Hille and Co., Ltd.

The writer is indebted to Mr. W. E. Fisher, of the Education Department, Uganda, for his assistance in making the drawings.

A Beehive (Bark Hive) Designed for the Production of Beeswax suitable for Use by Natives of the Uganda Protectorate.

1



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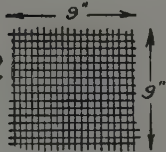

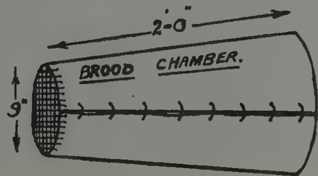

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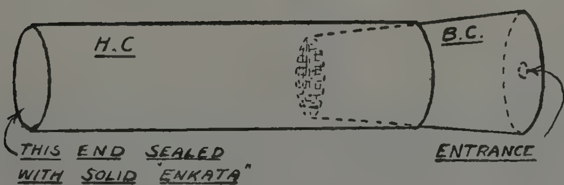

4

5

1. Honey-chamber of bark showing measurements and construction.
2. Piece of gauze for queen-excluder.
3. Brood-chamber complete with queen-excluder.
4. Completed hive with brood-chamber fitted into honey-chamber. "Enkata" means a pad.
5. Hive in position in tree, but not protected with grass.

PLATE 1

For the purpose of obtaining swarms, Kigezi beekeepers suspend their hives from trees.

PLATE 2

When swarms enter hives suspended in trees as shown in Plate 1, the Kigezi beekeepers remove them on to forked poles.

Note.—In most parts of Kigezi the honey-ratel is unknown.

PLATE 3
Extracting wax by means of a hessian bag and two sticks.

PLATE 4
Beekeepers in Kigezi with comb brought in for demonstration of wax extraction.

Variegated Coffee Bug (*Antestia* spp.) in Uganda

By H. HARGREAVES, *A.R.C.S., D.I.C., Government Entomologist, Uganda.*

The serious nature of the damage which can be caused by *Antestia* bugs is well known to most growers of Arabica coffee. The insect usually reaches pest status some six years or so after an area is first planted with the crop.

In Uganda, *Antestia* first came into prominence in 1916, when an outbreak occurred in Kyagwe County of Mengo District. Other areas of Buganda Province as well as Busoga and Masindi were affected; Masaka followed, and the later planted areas of Ankole, Toro and Bugishu and Kigezi became infested in due course.

Two species of *Antestia* occur on coffee in the Protectorate: *lineaticollis* in Masaka, Ankole, Kigezi, Toro and Mubende Districts; *faceta* in Mengo, Masindi, and Bugishu Districts. These until recent years were considered to be varieties of one species, but attempts to interbreed them failed to produce any but infertile eggs, and it was decided that the so-called varieties are distinct species. There appears, however, to be no marked difference in the habits, life-history, etc., of the two, and for the purposes of this article they may be treated as one species.

Outline of Life-history.

Eggs are laid usually on the lower surface of leaves, but they may also be laid on berries or stems and occasionally on other plants near to coffee. The eggs are closely arranged in clusters, usually of twelve, the number varying between ten and fourteen.

After four to nine days the bugs hatch out; they remain clustered near the egg-shells for a day or two, and then begin to feed, but they are not very active until after the first moult. Five moults occur at intervals of approximately six, seven, eleven, twelve and fifteen days; thus the bug becomes adult some seven weeks after hatching.

The adult female may start to lay eight days after the final moult. The length of one generation, egg to egg, is therefore about two months. A cluster of eggs is laid every three or four days, and the total number laid by one individual may exceed 300 during a period of 20 weeks. Adults may live for eight months.

It must be borne in mind that the length of the life-cycle and the rate of reproduction vary considerably according to temperature and food supply: higher temperatures and abundant young berry food favour the insect.

Description of Stages.

The egg is 1/24th in. long by 1/20th in. thick, and is attached by means of gum to the surface on which it is laid. At the apex is a faint circle outlining the lid which is raised by the bug when it hatches out. When first laid the colour is a very pale ash-grey; later the colour changes slightly to pale buff, and three days before hatching three faint purplish spots appear, one in the centre and two almost diametrically opposed on the edge of the apical cap. Infertile eggs become bluish-grey.

The nymph when newly hatched is 1/25th in. long and almost as broad. At first it is nearly white, but within a few hours the colour changes to black with a pair of orange-yellow spots near the middle of the upper surface. Until after

the first moult the bug is sluggish and feeds but little; later it is very active, and when disturbed hides readily in a cluster of berries, rarely falling off the plant. The nymph sucks the juices of young berries, flowerbuds and tender shoots, much preferring the berry as a source of food. After the first moult a pair of small spots on the head, a single small spot behind the head and another pair of small spots on the hind half of the back, all orange-yellow, are developed in addition to the larger pair near the middle; whitish lines also appear. There is a considerable increase in size at each moult, but the colour scheme and general appearance change but little until the fifth moult, when the wings become evident and the adult stage is reached.

The adult is black above, with a pair of orange spots on the central triangular area and a single orange spot just behind the head; in addition to these marks there are various white and orange lines. The bug is shield-shaped, and approximately 0.3 in. long by 0.2 in. broad, the male being somewhat smaller than the female.

The feeding habit of the adult is much the same as that of the nymph; young berries in which the beans are still soft being preferred. Ripe berries also are attacked, but the beans are then too hard for the bug's proboscis to penetrate, and no appreciable damage is done to the crop.

During dull days or the early morning or late afternoon the adult is rather sluggish; when disturbed the bug quickly takes cover in a cluster of berries or on the far side of the stem or leaf, and when further disturbed it runs towards the middle of the tree or falls to a lower branch or to the ground. In warm sunshine, the adult when disturbed readily uses its wings and is difficult to catch.

Feeding experiments have indicated that berry-food is essential for the reproduction of the bug, and that egg-laying is most prolific during the first four months of the development of the berry, while the beans are still soft. After this stage (in the presence of an even-aged crop) bug reproduction falls off. Where, however, a succession of small flowerings occurs, owing to weather conditions, uneven age of coffee plants or to other factors, breeding of the pest may be continuous.

Damage.

The bean tissues of the berry are soft and spongy during approximately the first four months of development, and such berries form the favourite food of *Antestia*. The extraction by sucking of the concentrated food leads to the formation of spotted or irregularly shaped beans, or, in the extreme, to useless, minute, shrivelled remains. The damage is not evident unless the berry is opened by cutting, or during pulping; beans badly damaged by sucking will float after pulping. In one coffee area, in addition to the mechanical damage, the bug appears to have been responsible for the introduction of a bean rot (probably *Nematospora*); this fungus produces black smelly bean material, which during pulping may taint the good coffee and thus reduce its value.

The more nearly mature and ripe berries are also attacked by the bug, but the feeding appears to be restricted to parts other than the seeds. Flowerbuds also may be sucked. In the absence or scarcity of berries, the young shoots are liable to attack; severe damage may then be caused by the stimulation of secondary and tertiary branches, resulting in a matted growth which must be carefully pruned before a crop can be produced.

FOOD PLANTS.

The only food plants (i.e. those on which *Antestia* can live and breed) so far recorded in Uganda are Arabica coffee and three species of *Canthium*, shrubs which are related to coffee. The bug shows no preference for *Canthium* in the vicinity of *Coffea arabica*.

Although a few *Antestia* nymphs were on one occasion found on Robusta coffee, this species appears to be unattractive to the bug, and it cannot even be included as a food plant.

NATURAL ENEMIES.

Two species of minute wasp-like parasites, *Microphanurus seychellensis* Nixon and *Hadronotus antestiae* Dodd, attack *Antestia* eggs, and assist considerably in the natural control of the bug. Both parasites attack also the eggs of *Agonoscelis versicolor* Fab., another shield bug, which feeds on *Leonotis africana*, a common weed in Uganda; weeds such as this may prove beneficial as reservoirs for the parasites during periods when no *Antestia* eggs are present.

Parasitized eggs become bluish-grey. The shells of bugs' eggs which have produced parasites have holes with jagged edges as opposed to clear-cut edges when bugs have hatched.

A parasite of little importance is the Tachinid fly. *Epineura rubens* Villen., the maggot of which lives in the body of the adult bug.

A praying mantis is a predator of *Antestia*, but since these insects are general feeders they prey on beneficial as well as injurious insects, and may thus at times be actually harmful.

It seems likely that several species of carnivorous ants, such as *Oecophylla smaragdina* and *Macromischoides aculeatus* (*Munyera*—Luganda), which build their nests between coffee (and other tree) leaves, play some part in the control of *Antestia*. In areas where the single-stem system of culture has been abandoned for some years in favour of multiple-stem growth, and especially those areas in close proximity to forest, these fierce, leaf-nesting ants become more and more commonly found on coffee trees; in such areas *Antestia* has in some instances ceased to be a pest, and it is possible that these carnivorous ants have played an important part in the control of the pest. Unfortunately, such ants are themselves a pest, since they (especially *Munyera*) have been known to deter labour from picking the crop, and measures have to be taken to control them.

CONTROL OF *Antestia*.

Since under the conditions maintained in coffee culture the natural enemies of the bug are often incapable of causing adequate diminution of the bug population, it becomes necessary to adopt artificial measures to combat the pest.

On some estates a reasonable degree of control has been achieved by continuous hand collection of bugs with the assistance of smoke. Search for bugs must be carried out during dull weather or during the early part of the day, when the adult does not readily fly when disturbed. Trees with dense foliage or very tall stems render collection difficult. The advantages of this method are: low cost (about Sh. 5 per acre per year); it can be carried out during wet weather conditions; it causes no reduction of the natural enemies. Its disadvantages are that supervision is difficult, and that it does not quickly reduce heavy infestations resulting from neglect of control measures.

A second method of control is that of arsenical spray-baiting. This appears first to have been used in Tanganyika Territory, where it is now fairly generally

employed by non-native coffee-growers. The bait consists of a solution of 2 oz. sodium arsenite and 2 lb. of sugar (or jaggery) in 4 gallons of water; it is applied upwards and into the middle of the tree by means of an atomizer (the best type of which is the "Fog" sprayer with a solid piston), one or two puffs sufficing for one tree. A series of three applications should be carried out at weekly intervals and during dry weather before flowering is due. The presence of crop less than four months old proves a serious counter-attraction for the bug, but satisfactory results have been obtained in the presence of older berries. Advantages of the spray-bait control are the rapidity with which a severe infestation can be reduced, the smaller risks of human error or slackness, and the comparatively low costs (being comparable with those of hand collection). Its disadvantages are that it is applicable successfully only during suitable weather condition and, in cases where crop is present, after the coffee beans have hardened; that it cannot be adopted by uneducated coffee-growers, and that parasites, not only of *Antestia* but also of other coffee pests, may be killed. Supervision is, of course, necessary to ensure that the spray is applied to the trees (not poured away), that foliage is not drenched and burnt, and that the labourers are not poisoned through handling the bait carelessly.

A third method of control is that devised and advocated in Kenya.* This consists of enclosing each coffee tree in turn with a cloth while kerosene extract of pyrethrum is applied by means of an atomizing spray. The extract is made by allowing lighting kerosene of high flash-point to percolate slowly through fresh, best quality pyrethrum powder, the normal strength being 1 gallon of kerosene to 1 lb. of pyrethrum. Collection and destruction of fallen bugs from each tree immediately after spraying is recommended to ensure that those bugs which are temporarily stupefied do not escape. The advantages claimed for this method are that almost 100 per cent kill is obtained, and that it can be applied successfully during the rainy season (during dry intervals when the foliage is dry). The disadvantages are: its high cost (in the region of Sh. 15 per acre per application); it is not applicable during very windy or rainy weather; the quality of pyrethrum is not dependable; it must, like the bait spray, kill such parasites as are present in the free living stage on the trees (wasp-like parasites, ants and other Hymenoptera are the first to be killed by the pyrethrum spray); considerable skill is necessary for the labour to give the correct dosage and avoid scorching of foliage. The quality of the pyrethrum is an all-important factor; this is shown by the fact that the writer has made various tests of extract, prepared in some cases from reputed fresh and best quality pyrethrum, and at best has succeeded in killing only a small proportion of the *Antestia* present, even after enclosure of the coffee plants for as long as ten minutes under closely woven cloth. The writer is assured, however, by his colleagues in Kenya that a satisfactory control can be secured by this method; this has been supported recently by the success of a planter in Kyagwe in controlling a small outbreak of *Antestia* by means of the pyrethrum extract.

A modification of the last-named spray has been advocated by Notley† for use

* Le Pelley: Bulletin No. 8 of 1934, Dept. of Agriculture, Kenya.

† Bulletin No. 4 of 1933, Dept. of Agriculture, Kenya.

against *Antestia* in wetter districts. This consists of soap emulsion of pyrethrum extract. The advantages as compared with kerosene-pyrethrum extract are: the cost per acre per spraying is about Sh. 3/30 (1933) less (the figures appear not to include cost of apparatus in either instance); less skilled labour and less close supervision are required; it can be applied at any season of the year. The disadvantages are that a high pressure sprayer must be used to ensure that the spray penetrates to all parts of the tree, and that the spray must actually wet the bugs in order to kill them.

Conclusion.

In view of the wide variation in quality of pyrethrum and of the great expense involved in the control of *Antestia* by sprays containing pyrethrum, these are unlikely to be used on any large scale in Uganda. Such sprays will have their use, no doubt, in testing density of bug population.

A combination of spray-baiting during suitable periods with hand collection between those periods is likely to prove the most suitable means of control applicable by non-native planters in Uganda.

[Since the foregoing article was written, Mr. Notley, Entomologist, Department of Agriculture, Kenya, has published an article on the use of pyrethrum dust against *Antestia* (*East African Standard*, January 10th, 1936). The technique is much simpler and the cost much less than in the case of the pyrethrum extract sprays. Provided the quality of the pyrethrum can be depended upon, it may economically be possible to control *Antestia* (and various other pests) in Uganda by means of pyrethrum dust.]

Vegetation Types and Water Supplies

By R. R. STAPLES, *Botanist, Department of Veterinary Science and Animal Husbandry, Tanganyika Territory.*

It seems fairly generally recognized now that the conservation of the all too meagre permanent water supplies is of vital importance to the population occupying by far the greater part of East Africa. As Gillman, in his thoughtful and constructive remarks in connection with his *Population Map of Tanganyika Territory* (1934), points out, the presence or absence of permanent water is the primary factor responsible for the distribution of the population in the Territory. His figures go to show that the one-fifth of the country which has good or fair water supplies supports five-sixths of the population. The remaining one-sixth occupies another one-fifth of "precariously watered land". No less than three-fifths of the country is completely unpopulated mainly, as Gillman maintains, through lack of permanent waters; yet most of this huge area of land (more than 200,000 square miles) has a rainfall sufficient to grow suitably chosen food crops in an average year.

In the precariously watered areas it is not uncommon for the domestic supplies to be obtained from distances of ten miles or more and severely taxing the powers of physical endurance of the unfortunate womenfolk. And yet if one takes the daily consumption rate at 4 gallons (an estimation given by the local District Officer) for a Gogo family in the Mpwapwa District living some distance from water, the run-off from an experimental one-eightieth of an acre plot at Mpwapwa and planted with a food crop, native fashion, would, if suitably stored, suffice for their domestic requirements for the best part of two years! The run-off from the same size plot kept free of vegetation has averaged out almost double this volume again (3,890 gallons as compared with 2,137 gallons).

As regards the protection of all inadequate water supplies, differences of opinion are becoming increasingly evident regarding the most effective measures towards this end. This is due largely to the fact that there is undoubtedly a dearth of exact information on the subject, particularly for semi-arid conditions, for the guidance of anyone endeavouring to lay down a sound policy. It is, for instance, a rather general belief that a forest cover, irrespective of climate or soil conditions, is the most effective vegetation cover for the conservation of spring flow. There seems to be, however, insufficient reliable data to support this conclusion, at any rate under semi-arid conditions, and in some of us confidence in the theory has been further shaken by the results obtained in some carefully carried out experiments in the United States of America. These experiments have been ably reported upon and searchingly discussed in Paper No. 1858 of the American Society of Civil Engineers, entitled *Forests and Stream Flow*, and one need only touch on them briefly here.

It appears that one of the American experiments was specially designed to show the beneficial effects of forests on stream flow, but the results unexpectedly tended to show the reverse! While stressing the need for further investigations before general application of the results could be made, the authors claim that under the conditions of the experiments a lesser vegetation cover (herbaceous or low scrub) definitely afforded better protection to the water supplies,

even at the period of minimum flow, than the original forest cover. It still remains to be proved how widely these results apply, but the possibility of their holding good for a wide range of conditions, and particularly in semi-arid areas, seems sufficiently probable and of such vital importance that the experiments deserve a closer examination.

In the Union of South Africa, too, where much interest is being taken in water-shed protection at the present time, forests, as a means of conserving permanent waters in areas of deficient rainfall, are being regarded with suspicion by some, as numerous observations tend to show that the planting of exotic trees (wattles, gums and even pines) in grasslands may adversely affect the spring flow from these areas. While the indigenous forest species may not have such an effect, this still requires definite proof.

To revert back to East Africa, one of my strongest first impressions of Tanganyika Territory was the meagre permanent waters when compared with areas of lesser rainfall in South Africa. But, while semi-arid South Africa is mostly short grassland or the well-known Karroo bush vegetation of a foot to eighteen inches in height, most of Tanganyika, and particularly where water supplies are the scantiest, is dense deciduous scrub or *myombo* forest, up to 30 feet or more in height. Frost and a lower mean average temperature in the lower latitudes seem to be the chief factors responsible for this great difference in the vegetation of the two areas. Admittedly geological differences may be an important factor affecting the water supplies, but is it not probable that the vegetation cover may be of greater importance?

Local Investigations.

At Mpwapwa, which seems peculiarly well suited for studies in water conservation in semi-arid East Africa, we have endeavoured in a small way to obtain some data which should aid in clarifying the position. Three lines of attack are being developed, namely:—

(1) The effect of clearing of riverine forest on streamflow.

(2) The comparative transpiration rate of different vegetation types.

(3) Rainfall penetration under different vegetation types.

Some Tentative Conclusions.

Progress reports on these investigations appeared in the 1934 Annual Report of the Department of Veterinary Science and Animal Husbandry, Tanganyika Territory, and can be consulted by anyone interested in the subject. While it is too early to draw definite conclusions, it may be said that the data so far obtained tend to support the conclusions drawn from the American experiments previously referred to, as: (i) The clearing of the riverine forest appeared to increase markedly the dry-season flow of the stream. (ii) The deciduous scrub type of vegetation, seemingly through its much larger bulk of foliage, appears to have a considerably higher transpiration requirement than the grassland under the same conditions. (iii) With a seasonal rainfall of 25 inches, moisture was found to penetrate to an average depth of only about 3 feet under deciduous scrub, whereas it penetrated almost 6 feet in the adjacent grassland. (iv) As soon as the rains stopped, the soil moisture under the scrub vegetation appeared to be depleted at an astonishingly greater rate than under grass. The main point which arises from the work accomplished so far is the large part of the rainfall which the unchecked vegetation seems to use under semi-arid East African conditions. This season we are extending the investigation to include

a study of the penetration of the rainfall in evergreen forest, as compared with that in adjacent *myombo* (*Brachystegia-Isoberlinia* savanna) and pure grassland.

Practical Applications.

One may well ask, even if one vegetation type, e.g. grassland, may be a superior vegetation cover in connection with water supplies than either scrub or forest, whether this fact would be of any practical value? The answer seems definitely, Yes. In East Africa, as in much of the Continent of Africa, it is generally held that most of the extensive grassland or savanna areas are only stages in the natural succession, and owe their stability mainly through the factor of fire. With the elimination of fires, therefore, they would tend to give way to more woody vegetation types. Strenuous efforts are actually being made to keep out fires in many forest and water-shed areas. Restrictions have also been put on the grazing of cattle in some areas, and it is not impossible that the grazing may actually perform a useful role in reducing transpiration losses if it does not result in an increase of the woody vegetation by reducing the competition with grass. Moreover, direct run-off and soil erosion from burnt or grazed grassland, providing these are judiciously carried out, may not be as high as is generally thought to be the case. In fact, some observations (1933 Annual Report) and actual data (*Grassland Problems in South Africa*, 1932, and unpublished data from an experiment at Mpwapwa) indicate that loss of water in this way, under certain conditions, may account for only a very small part of the precipitation. On the steep slopes of the Mpwapwa mountains, with the *myombo* vegetation burnt almost every year, a generous estimation of the run-off during the past five years is below one per cent of the rainfall. May it not reasonably be contended, therefore, that where water supplies are of paramount importance, until more definite information is available, any policy of intentionally increasing the vegetation, *beyond what is required to prevent undue run-off and soil erosion*, is of doubtful wisdom?

A further possibility which arises from these investigations and, if found to be true, may have far-reaching effects, is that the clearing and occupation of land in deciduous scrub or *myombo* areas (in other words, the production of "cultivation steppe") may actually improve the domestic supplies of water. A superficial examination of the often sharply defined islands of "cultivation steppe" in the Territory, surrounded, as they usually are, by enormous areas of almost or completely waterless but otherwise similar country, tends to support a supposition of this kind, but on closer examination other causes may be found to supply the true explanation.

In concluding this brief discussion of a subject admittedly contentious through the lack of reliable data, it is as well, too, to emphasize the apparent dangers of destroying both soil and water supplies by encouraging accelerated run-off through overstocking or faulty cultivation.

Conservation of Soil Fertility on Coffee Estates

With Special Reference to Anti-Erosion Methods

By G. H. GETHIN-JONES, *M.Sc., Soil Chemist, Department of Agriculture, Kenya.*

In coffee husbandry the maintenance of soil fertility is only one of many factors that make for successful coffee production. Insect and fungoid attacks may limit high yields where the soil fertility factor is highly favourable. Again, over extensive coffee-growing areas, it is rainfall and its distribution which determines the crop which the tree can carry to maturity despite all efforts made to improve the general fertility of the soil and to combat pests and diseases. Although much can be done by good soil husbandry to get the best value out of a limited rainfall, it is suitable rainfall and other climatic conditions that largely determine the choice and extent of our present strains of *Coffea arabica* in this Colony.

What do we mean by the term "soil fertility"? We mean the capacity of the soil to produce any specific crop—in this particular case, coffee. With most crops, yield or quantity is the main aim, but with coffee we need quantity plus quality. We wish that one could describe the fertility characteristics that would produce good yields of the kind of coffee favoured by coffee tasters and buyers. The main difficulty in correlating the liquoring properties of coffee with the parent soil and tree treatment is that it has not been possible to define liquoring properties in scientific terms. Incidentally it is difficult to assess the true chemical and physical properties of a soil that may play a part in determining the final liquoring properties of roasted coffee. As so many other husbandry factors, other than the dynamic properties of the soil, may exert their influence, it is likely that it will prove difficult to affect liquoring properties by soil treatment.

There remains the task of maintaining the general fertility of the soil so as to obtain the best returns, at least in quantity, according to the limitations set by biotic and climatic conditions. Soil fertility is a very wide term and perhaps one is rather apt to associate "fertility" with an abundance of available plant nutrients contained in the soil. The general fertility of any piece of coffee land over prolonged periods depends mainly on the depth, resistance to erosion, physical properties, more especially ample pore space resulting in free movement of soil water and soil air. Coupled with these permanent properties of the soil there is the humus-status and the nutrient-status of the soil, which must be maintained from year to year. Generally speaking, all problems in connection with the general fertility of a coffee soil can best be dealt with by preventing soil erosion and maintaining the humus content of the stationary surface soil. A well-drained deep virgin soil under good rainfall usually carries a dense natural vegetation which covers the land and keeps it cool, so that humus accumulates until it is in equilibrium with the natural destructive processes. When such a soil is broken up and planted with coffee, humus accumulation on the one hand is greatly reduced, whereas its destruction is accelerated by more open, warmer conditions. It would be uneconomical to attempt to maintain the soil humus at too high a level. The best that can be done is to prevent it falling so low that the lack of humus seriously affects the stability and inherent physical properties of the soil, the supply of nitrates, and the efficiency of manuring.

The conservation of general soil fertility is the summation of the conservation of the surface soil, the conservation of soil humus, the conservation of soil moisture, and the conservation of desirable physical properties and resistance to erosion. All these factors are interrelated and it happens that on the whole there is no direct clash of interests, but different cultural methods have to be used according to climatic conditions. The maintenance of a relatively high humus stable surface soil covers many of the conservation of fertility factors, and is of major importance in checking initial soil erosion. It is easier and cheaper to maintain a good surface soil than to build up a soil once it has started to deteriorate.

Let us deal briefly with certain of these conservation of fertility and anti-erosion factors, and show how they are interrelated.

Conservation of Soil Humus.

A suitable level of humus in the soil aids percolation of water, gives the soil better aeration and desirable physical properties. It makes for more even and plentiful supply of nitrates and other nutrients, more efficient manuring, and makes the soil more resistant to erosion. Varying methods have to be used to maintain the soil humus according to climatic condition and the special needs of any particular soil.

The maintenance of soil humus and the nitrate supply of the soil is easier where the rainfall is good, as here the growing of subsidiary leguminous crops and suitable weeds throughout a large part of the year can contribute a cheap supply of nitrogenous soil organic matter, and thus lessen the need of added material from outside sources. Again, the growth of a subsidiary crop during the rains helps to conserve much of the nitrates which would otherwise be leached out of the land by percolating waters which constitute the natural drainage.

In the drier coffee areas, where rainfall and its distribution is often a deciding factor, one has to resort more to the laborious and expensive method of supplying the greater part of soil organic matter by adding *boma* manure, compost or thatch. Where periodical clean cultivation is necessary, there is a still greater need of adding suitable material from outside sources. Over the greater part of the coffee areas of the Colony a combination of producing some organic matter in situ during the rains and supplementing this with some readily decomposable *boma* manure or compost is usually the more economical method.

One may well ask, "Why is it all-important to add these relatively small amounts of organic matter and its contained nitrogen to a soil which already contains more than a hundred times that quantity?" Soil analysis shows that the upper six feet of a typical red coffee soil contains as much as some 200 tons of organic matter, including some 7 tons of total nitrogen per acre. This vast amount of total nitrogen per acre is about equal to that contained in some 35 tons of sulphate of ammonia, and would have a nominal value of some £400 per acre. Why, with this vast amount of total nitrogen present in the soil, does the coffee tree sometimes show signs of nitrogen starvation which can be corrected by the addition of a relatively small dose of added available nitrogen? Mainly because the vast bulk of the total soil nitrogen is tied up in an unavailable form within the fairly stable residual organic matter. The natural decomposition of soil organic matter under uniform soil conditions reaches a fairly constant end point when the remaining organic matter becomes a more or less permanent constituent of the soil and its further decom-

position with liberation of nutrients becomes very slow. Thus readily decomposable material has to be added to meet the nitrate requirements of an exhausting crop.

In the more humid coffee areas one should aim at growing bulky green manures to prevent heavy leaching of nitrates into the subsoil beyond the range of roots, and at the same time to maintain the relatively high humus content of the surface soil. In the drier areas there is little fear of the ultimate leaching of nitrates to below root level; any surface excess of nitrates is washed down into the subsoil, where it helps to maintain the coffee tree during the prolonged drought. Lack of moisture limits the production of organic matter in situ; hence, apart from the growing of short-term green manures during the rains, one has to depend more on brought-in material in the form of thatch, compost or *boma* manure. In all cases, more especially where thatch is added, methods of maintaining the soil humus also constitute anti-erosion methods.

Conservation of Soil Moisture.

Coffee is grown under a wide range of rainfall conditions, varying from about 25 inches to about three times this figure. Furthermore, the distribution is often very irregular, more especially in the drier areas. In the latter, the growing of subsidiary green manure crops is strictly limited, and one has to resort to periodical clean cultivation as a means of conserving soil moisture. As the surface layers of soil become very dry, the coffee tree has to depend more and more on the sub-surface layers for water and nutrients. However, the dry surface soil forms a most efficient blanket or mulch, which protects the underlying layers of soil from further serious water losses to the atmosphere.

The lower soil holds a good reserve of moisture that is available to the coffee tree, provided that there are sufficient feeding roots distributed throughout this zone. Field work at the Scott Agricultural Laboratories has shown that a grass mulch is highly suitable for conserving moisture throughout the soil profile; a soil mulch dries the top-soil but conserves moisture below. A wide margin of some 7 per cent by weight of moisture content can be conserved in the subsoil; this is equivalent to some 10 inches of rain retained in 8 feet of subsoil during the rains and available to plant growth during subsequent drought. It is partly the residue of rains of previous years retained in the subsoil that has assisted the local coffee tree during the recent years of prolonged drought. In the drier areas it is necessary to develop the subsoil reserves so as much as possible of heavy downpours of rain should enter the soil and not leave the land as run-off water. The usual anti-erosion measures not only conserve surface soil but also soil water.

Conservation of Desirable Physical Properties.

The benefits of cultivation in the case of a permanent crop like coffee are less obvious than with annual crops, where the need of a suitable tilth for seeding and the subsequent ploughing up of the stubble land are very marked. The undisturbed red subsoil at the Scott Agricultural Laboratories was found to have a pore space of about 57 per cent and "solid matter" about 43 per cent, both values being expressed by volume. These values show ample aeration, even when holding the great reserves of soil water of about 25 per cent by weight or some 40 per cent by volume, when there would still be some 17 per cent by volume occupied by the soil air. Provided that we attend to the surface soil, the structure

of the subsoil, where there is good depth, can usually take care of itself. There remains the periodical cultivation of the surface soil and envelope forking or subsoiling to loosen the compacted surface soil, so that it permits the free movement of soil air and soil water in the subsoil.

Under natural conditions, under forest or bush, the surface layer of soil is usually very friable and is open in texture. This is brought about by the decay of soil litter and the activities of the soil fauna which abound in their shaded and suitable environment. The vegetable mulching of most Kenya coffee soils brings about similar conditions. Under such a mulch we find a rich, moist, puffed-up soil, which receives the available nutrients liberated at the rotting base of the mulch. Vegetable mulch is best applied after a rough cultivation at the end of the rains. Such a mulch overlying a very open surface soil bestows upon the soil an ideal protection against beating rain and scorching sun. It will be noted that this method of conserving desirable physical properties by periodical mulching also constitutes an anti-erosion and water conservation measure in the drier areas, especially where the soil is poor or on a fairly steep slope, and hence liable to erode. In the wetter areas the growing of cover crops gives rise to desirable soil properties. Their continued growth and incorporation results in added organic matter, and they check the leaching of nitrates and soil erosion. It will be noted that a more highly coloured soil, low in organic matter, compacts more readily than a darker, richer soil. It is this natural packing, impeding the movement of soil air and soil water, that has to be overcome. The best time for periodical cultivation will vary throughout the Colony. It should follow the usual period of picking and pruning, and as far as possible the soil should be in the form of a rough tilth from the beginning of the seasonal dry weather.

It will be noted that cultural methods adopted to maintain desirable physical properties also constitute anti-erosion measures; however, a loose cultivated soil on sloping land has to be protected by the mechanical treatment of these slopes.

Conservation of the Nutrient-status.

The needs of the red coffee soils are mainly nitrogen and phosphates. It is believed that on the whole the demand for potash is limited, and it is not likely to be a limiting factor in the manuring of coffee. The most economical way of supplying nitrogen from outside sources is through a leguminous crop, *boma* manure, or a properly prepared compost; thus this aspect of manuring also falls into line with other methods of maintaining fertility: that is, one helps to conserve soil moisture, soil humus, desirable physical properties, and again organic manuring in itself constitutes an anti-erosion measure. It is suggested that the general level of the nutrient-status can best be maintained by adding nitrogenous organic manures, that soluble phosphate be added via the compost pit, and that by-product phosphatic manures may be given direct. However, there often remains the need of supplying additional amounts of available nitrogen as a productive top-dressing when the trees are under the strain of carrying a heavy crop. In highly productive areas, where the soil has a high humus content, it is likely that one can also apply mixed or compound fertilizers to supplement the organic manures. Where there is no soil erosion a higher level of nutrient-status makes for more vigorous growth of coffee and subsidiary crops; hence in many ways reducing the risk of surface erosion, whereas if erosion takes place this im-

provement is limited, and intensive manuring becomes wasteful and uneconomical: control of erosion must precede intensive manuring.

It will be noted that good husbandry methods in themselves as soil treatments also constitute indirect anti-erosion measures. These alone are not sufficient, except in the case of a well-covered soil where the slope is very gentle. It would be wasteful to pay too much attention to these subsidiary methods of treating the soil if we neglect the more obvious methods of treating the slopes as well.

DIRECT ANTI-EROSION MEASURES.

We can best deal with the treatment of slopes under two headings:—

(1) Treatment of land previous to planting.
(2) Treatment of established coffee lands.

Land Previous to Planting.

Where new land that is liable to erosion is being planted with coffee it is advisable that the land be prepared in a series of broad-base ridge terraces. In the case of the more impervious coffee soils, the terrace itself should be graded (Mangum terrace), so that surplus water may be carried off the land. The essentials of a broad-base terrace are that they should be properly surveyed, spaced and prepared, and that water from higher land be diverted. A detailed account of the laying of such broad-base terraces is given in the recent departmental bulletin on soil erosion. The actual cost of making Mangum broad-base terraces on maize land at Kitale has worked out at some Sh. 3 and Sh. 1/75 per acre respectively, with and without European supervision. Such terraced land could be planted with cover crops along the contour, while the newly planted coffee occupies only a small portion of the ground.

The problem with established coffee lands is more difficult, as slope treatments must be limited by the necessary small disturbance of the soil. According to slope, erodability of the soil and climatic conditions, one must choose such methods as cover-cropping, contour hedges, silt pits, box terracing, and narrow-base ridge terracing.

There is no doubt that contour cover-cropping is a cheap and efficient method where the soil is porous and the slope moderate. On reaching a firm belt of cover-crop the flow of any surface water is arrested, silt is deposited, and the surplus water is usually absorbed by the very porous open soil that underlies a mature cover-crop. Temporary complete covers, such as a close growth of quick-growing weeds, which come up during the rains, also constitute an efficient anti-erosion method, more especially in the more humid areas. The growth is repeatedly slashed before the tissues harden but deeper cultivation becomes necessary, say at least once a year, before picking and pruning. Thus such a plant as *McDonaldi* (*Galinsoga parviflora*) has become an important factor in the maintenance of the general fertility over wide coffee-growing areas. Natural weeds should be low growing, making responsive growth to rains and dying down during dry weather, and should be easily controlled. *Grass weeds must be excluded.* The counterpart in the drier areas, and where the soil is less porous, and on steeper slopes, is the practice of heavy thatching with undecomposed vegetable matter.

Contour hedging is another method. These must be low and of a kind that the below and above ground portions are firm and in close formation, so that the underlying soil is held by the roots and any surface creep of soil is arrested.

Some of the most useful plants for this purpose include Mexican Daisy (*Erigeron mucronatus*), Babu's Delight (*Telanthera*).

Again, larger plants, such as Elephant (Napier) grass and Vetivert grass, may be used as major contour hedges or strips on steep slopes and at the lower edge of coffee lands.

The Mechanical Treatment of Slopes.

In heavy rainfall districts, on steep slopes, or where the soil is less porous, there is apt to be much water which cannot percolate into the soil while it is still raining. This surplus water collects on the surface and soon begins to flow down the slope. This has to be checked before it has reached a sufficient velocity to transport soil particles; in other words, the purpose of pits and terracing is to limit the local catchment areas of surplus water. Pits and terraces must be so proportioned and placed that they can deal with the volume of water that is apt to collect above them during very heavy rain. In cases of heavy downpours in high rainfall districts which do not suffer from drought, the main need is to conserve the soil; part of the surplus water after the deposition of most of the silt can be allowed to drain away, thus lessening the leaching effect by the passage of this water through the soil and subsoil into the natural drainage system.

We have the choice of several methods such as silt pits, short channels with accompanied terraces, narrow-base ridge terraces, and box-terracing. We cannot lay down any rules that certain types of slope treatment are ideal for any slope or locality. The factors which govern the choice overlap and different systems may have their own merits for any piece of land. What are the factors which should determine the method used? We may mention total rainfall and the likelihood of heavy downpours, the need for conserving soil water for drought periods, the slope of the land, and the permeability and erodability of the soil. What would be the special conditions favouring specific methods of treatment? One would associate silt pits with steep slopes, less porous soils, high total rainfall with little fear of drought. A less porous soil and a higher rainfall would counterbalance a less steep slope. Silt pits are usually associated with steep slopes, as under these conditions the reservoir for surplus water cannot have a large surface area and therefore must be deep. Under heavy downpours silt pits are liable to overflow and must be connected by an open graded channel below ground level, so that during periods when the run-off is very great, surplus water flows along the chain of pits and is eventually discharged into a prepared drain. Under conditions less exacting than the above as regards slope and rainfall, and where the local topography is much broken, strip channels, with the excavated earth forming a terrace, can be used.

Box-terracing is very suitable for areas with gentle slopes in low rainfall areas which are subjected to heavy downpours coupled with long drought, and where it is essential to conserve and to have a uniform distribution of the water that falls on the land. Box-ridging would also pertain to less porous soils, thus allowing time for a local heavy fall of rain to soak into the soil. One useful featuring of box-ridging is that their preparation can be coupled with hand-weeding and cultivation methods. The weeds and about an inch or so of soil are drawn and laid in a ridge between the rows along the nearest contour. The second cleaning of the land builds up another ridge at right angles to

the first. These small ridges will contain most of the weeds, which rot within the soil ridge. Should the slope be appreciable and diagonally across the main lines of coffee, then one side of the box-ridge should also be laid diagonally so as to face the slope. When there is a danger of box-ridges overflowing, then it is necessary to have graded narrow-ridge terraces and their associated channels at intervals. They would limit the area subjected to overflow water, and the latter could be conveyed to where it can do no harm.

Perhaps the cheapest and most adaptable system of treating the soil slope is by the use of the narrow-ridge contour terrace at intervals according to the slope. However, this system differs from the others in that the terraces must be properly spaced and carefully laid out by proper levelling instruments, and afterwards maintained, otherwise they may cause collected surplus water to overflow at the lowest level or at a weak point in the terrace. This release of accumulated water would be likely to break through other terraces further down the slope, with the liberation of further amounts of accumulated water. Under conditions of high rainfall, fairly steep slopes, or a fairly impervious soil, there is likely to be much run-off water which cannot soak sufficiently rapidly into the soil behind the terrace. The best precaution under these conditions is to have the channel and terrace graded so that surplus accumulated water is led off the coffee lands.

The best methods of laying out terraces have been described in detail in the recent departmental bulletin on soil erosion. One has to decide whether the narrow-ridge terraces should be level terraces or graded terraces. With certain exceptions, an adapted level terrace or a dual purpose terrace could be used over the major portion of the coffee areas, more especially in the porous soils which are derived from volcanic lava, which are well provided with humus and need the whole of the annual rainfall for carrying the heavy bearing coffee tree through drought periods. Such terraces would be level, but precautions would be taken to arrange that they would overflow under controlled conditions into drainage channels during exceptionally heavy downpours. The surplus water from graded terraces and adapted level terraces must be discharged into a properly graded drainage channel.

Terraces of the above type have been laid out at the Scott Laboratories. They were just able to hold an inch-and-a-half downpour of rain. We have a good deal to learn about the most efficient spacing of narrow-base terraces for different parts of the Colony. The ideal terracing would aim at catching the maximum amount of water; that is, a level terrace, and yet making an allowance for the safe removal of surplus water collecting after exceptionally heavy downpours, which would otherwise overflow the terrace and cause serious erosion. Overflow would occur under controlled conditions at the end of the terrace before it would overflow elsewhere. The suitable dimensions of the ridge would appear to be some nine to twelve inches high and some two to three feet at the base. The position of the coffee trees would have to be more or less ignored, and once built the terraces would have to be maintained by hand cultivation. The cost of such terraces is estimated at something between Sh. 1 and Sh. 5 per acre, according to the soil slope.

Lastly, there is need to stress the importance of having a vegetal cover on the terrace, so as to consolidate and hold the soil and to enhance its value as an anti-erosion measure.

A Revised List of Plant Diseases in Kenya Colony

By J. McDONALD, *D.F.C., B.Sc. (Hons.), F.L.S., Senior Plant Pathologist, Kenya Colony.*

Since the last list of the plant diseases of Kenya Colony (1) was prepared in 1929, many new records have accumulated. These are now incorporated in the present list, which is believed to be as complete as possible at the time of preparation (February, 1936).

Among the most important crop diseases reported during the last few years is "take-all" of wheat (*Ophiobolus graminis* Sacc.), which has proved destructive in certain wheat-growing districts at the higher altitudes. (4)

Two new physiologic forms of wheat stem rust (*Puccinia graminis* Pers.) have been discovered since the last list of diseases was published. (2) In view of the fact that the aecidial stages of different physiologic forms of this rust are known in temperate climates to be capable of hybridization on barberry, with the production of entirely new forms, some alarm was felt in 1930 when an aecidial rust was found on indigenous barberries in Kenya. Subsequent study, however, showed beyond reasonable doubt that the latter rust is not a stage in the life-cycle of wheat stem rust, but is in all probability a species new to science. (3)

In maize, *Gibberella saubinetii* (Mont.) Sacc., recorded in the previous list as the cause of pink ear rot, has since been recognized as producing a seedling blight and root and stalk rots also. The closely related fungus, recently identified as *Gibberella Fujikuroi* (Saw.) Wollenw., var. *subglutinans* Edw., also causes very similar maize diseases in Kenya. (4)

In 1931 and 1932, Wallace published accounts of his discovery in Tanganyika Territory of the connection between infestation of coffee by the bug, *Antestia lineaticollis* Stahl., and the presence of the fungi, *Nematospora coryli* Pegl. and *N. gossypii* Ashby and Nowell, in decayed coffee beans contained in apparently outwardly sound berries. (5) (6) These two organisms have both since been found in similarly affected beans in Kenya, and are undoubtedly the cause of considerable damage. *N. gossypii* has also been isolated from cotton bolls affected by internal boll disease.

The presence of the fungus *Empusa grylli* Fresen. in Kenya is worth recording, although, as it is not the cause of a plant disease, it cannot be included in the list below. It was found on locusts (*Locusta migratoria migratorioides* R. and F.) in 1931, and caused considerable mortality among the pest at various times during the invasions which the country suffered over a period of years. The same fungus has also been observed on different kinds of grasshoppers, including *Catantops* sp.

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List of Diseases.

ACACIA (*Acacia melanoxylon* R. Br.).
In root, *Rhizoctonia bataticola* (Taub.) Butler ("A" strain of Haigh).

ALCHEMILLA, Indigenous (*Alchemilla* sp.).
Rust, *Puccinia aliena* Syd.)

ALMOND (*Prunus communis* Fritsch.).
Crown gall, *Bacterium tumefaciens* Sm. and Towns.

APPLE (*Pyrus malus* L.).
Canker, *Physalospora cydoneae* Arnaud.
Dieback, *Sclerophoma mali* (Brun.) Syd.
Bitter Rot, *Glomerella cingulata* (Ston.) Spauld. and v. Schr.
Cracking disease. *Coniothecium chomatosporum* Corda associated, though very doubtfully the cause.
Circular spot, *Phyllosticta pyrina* Sacc.
Scab, *Venturia inaequalis* (Cke.) Wint.
Root disease, *Botryodiplodia Theobromae* Pat. (associated with white ant damage).

APRICOT (*Prunus Armeniaca* L.).
Rust, *Puccinia pruni-spinosae* Pers.

ASPARAGUS (*Asparagus officinalis* L.).
Rust, *Puccinia asparagi* D.C.

AVOCADO PEAR (*Persea americana* Mill.).
Alga leaf spot, *Cephaleuros mycoidea* Karst.

BAMBOO, Indigenous (*Arundinaria alpina* K. Schum.).
On stem, *Engleromyces Goetzii* P. Henn.

BANANA (*Musa sapientum* L.).
Anthracnose, *Gloeosporium musarum* Cooke and Massee.

BARBERRY, Indigenous (*Berberis Holstii* Engl.).
Rust, *Aecidium* sp.

BARLEY (*Hordeum vulgare* L.).
Covered smut, *Ustilago hordei* (Pers.) Kell. and Sw.
Loose smut, *Ustilago nuda* (Jens.) Kell. and Sw.
Black rust, *Puccinia graminis* Pers.
Yellow rust, *Puccinia glumarum* (Schm.) Eriks. and Henn.
Leaf blotch, *Rhynchosporium secalis* (Oudem.) Davis.
Stripe, *Helminthosporium gramineum* Rabenh.
Net blotch, *Helminthosporium teres* Sacc.
Spot blotch, *Helminthosporium sativum* P.K. and B.

BAUHINIA, Indigenous (*B. fassoglensis* Kotschy).
Rust, *Uromyces pustulatus* Wakef.

BEANS.
RUNNER BEAN (*Phaseolus vulgaris* L.).
Rust, *Uromyces appendiculatus* (Pers.) Lev.
Anthracnose, *Colletotrichum Lindemuthianum* (Sacc. and Magn.) Bri. and Cav.
Leaf spot, *Isariopsis griseola* Sacc.
Halo blight, *Bacterium medicaginis* var. *phaseolicola* (Burk.) Link. and Hall.
Mosaic, virus.
BROAD BEAN (*Vicia Faba* L.).
Rust, *Uromyces Fabae* (Pers.) de Bary.
Leaf spot, *Ascochyta pisi* Lib.

BEET (*Beta vulgaris* L.).
Leaf spot, *Cercospora beticola* Sacc.

BROOMCORN (*Sorghum vulgare* Pers.).
Smut, *Sphacelotheca sorghi* (Lk.) Clinton.

BULRUSH MILLET (*Pennisetum typhoideum* Rich.).
Green ear disease, (?) *Sclerospora graminicola* (Sacc.) Schroet.
Rust, *Puccinia Penniseti* Zimm.
Smut, *Tolysporium Penicillarieae* Bref.
On heads, *Cerebella cenchroides* Subram.

CAPPARIS, Indigenous (*Capparis* sp.).
Rust, *Uredo Scheffleri* Syd.

CARNATION (*Dianthus caryophyllus* L.).
Rust, *Uromyces caryophyllinus* (Schrank.) Wint.
Leaf spot, *Heterosporium echinulatum* (Berk.) Cke.
Leaf spot, *Septoria dianthi* Desm.

CASSAVA (*Manihot utilissima* Pohl.).
Leaf spot, *Cercospora henningsii* All.
Mosaic, virus.

CASTOR BEAN (*Ricinus communis* L.).
Rust, *Melampsorella Ricini* (Biv.) de Toni.

CELERY (*Apium graveolens* L.).
Leaf spot, *Septoria Apii* Chester.

CITRUS spp.
Anthracnose, *Colletotrichum gloeosporioides* Penz.
Leaf spot, *Colletotrichum gloeosporioides* Penz.
Blue mould, *Penicillium italicum* Wehm.
Foot rot (associated with), *Fusarium Limonis*, Briozi.
Algal leaf spot, *Cephaleuros mycoidea* Karst.
Dieback, physiological.
Concentric ring blotch, physiological (symptoms as in South Africa).

ORANGE (*Citrus sinensis* Osbeck.).
In roots, *Coniosporium geophilum* Sacc. and Trotter (provisional).
Pink disease, *Corticium salmonicolor* B. and Br.
On twigs, *Septobasidium* sp., associated with scale (*Lepidosaphes beckii* Newm.).
On dead stumps, *Polystictus occidentalis* (Kl.) Fr. (? parasitic).
Dieback, physiological.
Black tip, physiological.
Chlorosis, physiological.

CLEMATIS, Indigenous (*Clematis* sp.).
Rust, *Aecidium englerianum* P. Henn. and Lind.

CLOVER, Indigenous (*Trifolium* sp.).
Rust, *Aecidium* sp.

CLUYTIA, Indigenous (*C. Richardiana* Muell. Arg.).
On leaves, *Cladosporium herbarum* (Pers.) Link.

COCKSFOOT GRASS (*Dactylis glomerata* L.).
Rust, *Puccinia graminis* Pers.

COFFEE (*Coffea arabica* L.).
Leaf disease, *Hemileia vastatrix* B. and Br.
Brown blight of leaves, *Glomerella cingulata* (Ston.) Spauld. and v. Schr.
Brown eye spot, *Cercospora coffeicola* B. and Cke.
Sooty mould, *Capnodium brasiliense* Puttem. (following scale insects).
Anthracnose, *Colletotrichum coffeanum* Noack.
Pink disease, *Corticium salmonicolor* B. and Br.; also "Necator" stage.
Seedling disease, *Rhizoctonia solani* Kuehn.
Berry or black berry disease, attacking green berries, *Colletotrichum coffeanum* Noack. var.
Brown blight, attacking ripe or ripening berries, *Colletotrichum coffeanum* Noack.
Bean disease, *Nematospora coryli* Pegl. and *N. gossypii* Ashby and Nowell, associated with infestation by the coffee bug (*Antestia lineaticollis* Stal.).
Root diseases:
Splitting disease, believed due to *Armillaria mellea* (Vahl.) Fr., but fructification not seen.
Brown root disease, believed due to *Fomes Lamaoensis* Murr., but fructification not seen.
Sclerotial disease, *Rhizoctonia bataticola* (Taub.) Butl.
On fruits, *Botrytis* sp. (? *B. cinerea* Pers.).
On stems of seedlings, *Pestalozzia funerea* Desm.

COMBRETUM, Indigenous (*C. tavatense* Engl.).
On leaves, *Asterina Combreti* Syd.

COTTON (*Gossypium* sp.).
Anthracnose, *Glomerella gossypii* (Southw.) Edg.
Internal boll disease, *Nematospora gossypii* Ashby and Nowell, associated with infestation by stainers (*Dysdercus* sp. and *Oxycarenus* sp.).
Leaf mildew, *Ramularia areola* Atk.

COWPEA (*Vigna Catjang* Walp.).
Leaf spot, *Septoria* sp. near *S. glycines* Hemmi.
On leaves, *Woroninella dolichi* (Cke.) Syd.
Mosaic, virus.

CROTALARIA, Indigenous (*C. agatiflora* Schw.).
Rust, *Aecidium Crotalariae* P. Henn.

CUCUMBER (*Cucumis sativus* L.).
Mildew, *Erysiphe cichoracearum* D.C.
Scab, *Cladosporium cucumerinum* Ell. and Arth.
Downy mildew, *Peronoplasmopara cubensis* (B. and C.) Clint.

CYPERUS, Indigenous (*Cyperus* sp.).
Smut, *Cintractia axicola* (Berk.) Cornu var. *minor* Clint.

CYPRESS (*Cupressus macrocarpa* Hartweg).
Pink disease, *Corticium salmonicolor* B. and Br.

DATE PALM (*Phoenix dactylifera* L.).
False smut, *Graphiola phoenicis* (Moug.) Poit.

DATURA (*Datura stramonium* L.).
Leaf spot, *Alternaria crassa* (Sacc.) Rands.

DIOSCOREA, Indigenous (*Dioscorea* sp.).
Rust, *Uredo Dioscoreae* P. Henn.

DIPLOTAXIS, Indigenous (*Diplotaxis* sp.).
White blister, *Cystopus candidus* de Bary.

ERLANGEA, Indigenous (*E. tomentosa* S. Moore).
Rust, *Puccinia Erlangeae* Grove.

EUPHORBIA (*Euphorbia heterophylla* L.).
Rust, *Uredo Euphorbiae-Engleri* P. Henn.

FIG (*Ficus carica* L.).
Rust, *Uredo Fici* Cast.

FLAX (*Linum usitatissimum* L.). (*See* also Linseed.)
Wilt, *Fusarium Lini* Bolley.
Browning disease, *Polyspora Lini* Lafferty.

GARLIC (*Allium sativum* L.).
Rust, *Puccinia porri* (Sow.) Wint.

GLADIOLUS.
Rust, *Uromyces tranversalis* (Thuem.) Wint.

GLYCINE (*Glycine javanica* L.).
Leaf disease, *Woroninella dolichi* (Cke.) Sydow.

GRAM, BLACK (*Phoseolus mungo* L. var. *radiatus*).
Mosaic, virus.

GRAM, GREEN (*Phaseolus mungo* L.).
Mosaic, virus.

GRAPE (*Vitis* spp.).
Anthracnose, *Gloeosporium ampelophagum* (Pass.) Sacc.
Mildew, *Uncinula necator* (Schw.) Burr.
Grey mould, *Botrytis cinerea* Pers.
On vines, *Pestalozzia uvicola* Speg.

GRASSES, Indigenous—
Aristida sp.
Smut, *Ustilago goniospora* Massee.
Brachiaria brizantha Stapf.
Rust, *Uredo* sp.
Leaf spot, *Phyllachora* sp., probably *P. heterospora* Henn.
Cerebella panici Tracy and Earle, following *Sphacelia* sp.
Cynodon dactylon Pers.
On inflorescence, *Cerebella cynodontis* Syd.
On inflorescence, *Fusarium heterosporum* Nees.
Cynodon plectostachyum Pilg.
Rust, probably *Puccinia cynodontis* Desm.
Cynodon sp. (? *plectostachyum* Pilg.).
Smut, Ustilago cynodontis (P. Henn.) Bref.
Digitaria nitens Rendle.
Cerebella cynodontis Syd.
Digitaria sp.
Rust, *Uredo digitariaecola* Thuem.
Eragrostis papposa Steud.
Rust, probably *Uromyces eragrostidis* Tracy.
Eragrostis sp.
On leaves, *Leptostromella septorioides* Sacc. and Roum.
Panicum maximum Jacq.
Smut, *Ustilago heterospora* P. Henn.
Pennisetum cenchroides Rich.
Rust, *Puccinia* sp., probably *P. Penniseti* Zimm.
Pennisetum clandestinum Hochst.
On leaves, *Mucilago spongiosa* Morgan (*Myxomycete*).
Setaria aurea A. Br.
Smut, *Ustilago heterospora* P. Henn.
Beniowskia Penniseti Wakef.
Setaria verticillata P. Beauv.
Rust, *Uromyces Setaria-italiceae* (Diet.) Yoshino.
Setaria sp.
Fusarium heterosporum Nees.
Sporobolus (?) sp.
On inflorescence, *Epichloe cinerea* B. and Br.
Themeda triandra Forsk.
Smut, *Sphacelotheca Themedae* Duke.
Tricholaena rosea Nees.
Phyllachora Tricholaenae P. Henn.

GROUNDNUT (*Arachis hypogaea* L.).
Leaf spot, *Cercospora personata* (Berk. and Curt.) Ell. and Ev.
From root, *Rhizoctonia bataticola* (Taub.) Butler ("C" strain of Haigh).
Rosette, virus.

GUAVA (*Psidium Guajava* L.).
Ripe rot, *Glomerella cingulata* (Ston.) Spauld. and v. Schr.
Pink disease, *Corticium salmonicolor* B. and Br.

HIBISCUS, Indigenous (*H. diversifolius* Jacq.).
Leaf spot, *Phomopsis malvacearum* (West.) Died.

HYPERICUM (*Hypericum* sp.).
Rust, *Soratаea* sp.

JUNIPER, Indigenous (*Juniperus procera* Hochst.), East African Cedar.
Heart rot, *Fomes juniperinus* Schrenk.
Sooty mould, *Hormiscium pinophilum* (Nees.) Lindau.
On galls, *Ceratostoma juniperinum* Ell. and Ev.

LEGUMINOSEAE (? genus).
On leaves, *Parodiella perisporioides* Speg.

LEMON GRASS (*Cymbopogon citratus* Stapf.).
Rust, *Puccinia cymbopogonis* Mass.

LEONOTIS, Indigenous (*Leonotis* sp.).
Rust, *Puccinia leonotidicola* P. Henn.

LILY (*Lilium philippinensis*).
Mosaic, virus.

LINSEED (*Linum usitatissimum* L.). (*See* also Flax.)
Rust, *Melampsora lini* (Lk.) Desm.
From root, *Rhizoctonia bataticola* (Taub.) Butler ("C" strain of Haigh).

LIPPIA, Indigenous shrub (*Lippia asperifolia* Rich.).
Rust, *Aecidium* sp.

LOBELIA, Indigenous (*Lobelia* sp.), Tree Lobelia.
Phomopsis Lobeliae (B. and Br.) Petch.

LOQUAT (*Eriobotrya japonica* Lindl.).
Pink disease, *Corticium salmonicolor* B. and Br.

LUCERNE (*Medicago sativa* L.).
Anthracnose, *Colletotrichum trifolii* Bain.
Rust, *Uromyces striatus* Schroet.
Leaf spot, *Pseudopeziza medicaginis* (Lib.) Sacc.

LUPIN (*Lupinus termis*).
Rust, *Uromyces renovatus* Syd.

MAIZE (*Zea Mays* L.).
Head smut, *Sorosporium reilianum* Kuehn) McAlp.
Seedling blight, root, stalk, and pink ear rots, *Gibberella saubinetii* (Mont.) Sacc.
Seedling blight, root, stalk, and blue ear rots, *Gibberella Fujikuroi* (Saw.) Wollenw. var. *subglutinans* Edw.
Leaf blight, *Helminthosporium turcicum* Pass.
Rust, *Puccinia Maydis* Bereng.
Diplodia dry rot, *Diplodia zeae* (Schw.) Lev.
Nigrospora dry rot, *Nigrospora oryzae* (B. and Br.) Petch.; *Nigrospora sphaerica* (Sacc.) Mason.
On leaves, *Fusarium Zeae* (West.) Sacc.
From seeds, *Colletotrichum graminicolum* (Ces.) Wilson.
From seeds, *Penicillium* sp. near *P. pinophilum* Hedgecock.
From vascular bundles, *Cephalosporium acremonium* Fresen.
On leaf spot, *Papularia sphaerosperma* (Pers.) von Hohnel.
Streak, virus.

MANGO (*Mangifera indica* L.).
Leaf spot, *Gloeosporium mangiferae* Henn.

MARROW (*Cucurbita pepo* L.).
Mildew, *Erysiphe cichoracearum* D. C.

MTAMA (*Sorghum caudatum* Stapf.).
Head smut, *Sorosporium reilianum* (Kuehn) McAlp.
Loose smut, *Sphacelotheca cruenta* (Kuehn) Potter.
Grain smut, *Sphacelotheca sorghi* (Lk.) Clinton.
Rust, *Puccinia purpurea* Cke.
On heads, *Cerebella sorghi-vulgaris* Subram.

MULBERRY (*Morus* sp.).
Leaf spot, *Septogloeum Mori* (Lev.) Brios. and Cav.

OATS (*Avena sativa* L.).
Smut, *Ustilago Avenae* (Pers.) Jens.
Stem rust, *Puccinia graminis* Pers.
Crown rust, *Puccinia coronata* Corda.

OLIVE, Indigenous (*Olea* sp., ? *O. chrysophylla* Lam.).
On trunk, *Fomes yucatanensis* (Murr.) Sacc. and D. Sacc.

PEA (*Pisum sativum* L.).
Mosaic.

PEACH (*Prunus persica* L.).
Mildew, *Sphaerotheca pannosa* (Wallr.) Lev.
Rust, *Puccinia pruni-spinosae* Pers.
Leaf curl, *Exoascus deformans* (Berk.) Fckl.

PEAR (*Pyrus communis* L.).
Dieback, *Sclerophoma mali* (Brun.) Syd.
Canker, *Physalospora cydoneae* Arnaud.
Cracking disease, apparently identical with that affecting apple.
Root disease, *Ustulina zonata* (Lev.) Sacc.
From root, *Peraneutypa* sp.

PEPPERMINT (*Mentha piperita* L., and *M. arvescens* Holmes var. *piperascens*).
Rust, *Puccinia menthae* Pers.

PLUM (*Prunus* sp.).
Crown gall, *Bacterium tumefaciens* Sm. and Towns.
On bole of living tree, *Ganoderma lucidium* (Leyss.) Karst.

PODOCARPUS, Indigenous (*P. gracilior* Pilg.).
Seedling disease, *Rhizoctonia* sp.
On leaves, *Corynelia uberata* Fr.

POTATO (*Solanum tuberosum* L.).
Early blight, *Macrosporium solani* E. and Mart.
Black scurf, *Rhizoctonia solani* Kuehn.
Powdery scab, *Spongospora subterranea* Wallr.

Storage rots, *Fusarium* spp.
Hollow heart, cause unknown.
Virus diseases (leaf-roll, mosaic, crinkle, streak).

PUMPKIN (*Cucurbita pepo* L.).
Leaf spot, *Septoria cucurbitacearum* Sacc.

QUINCE (*Cydonia oblonga* Mill.).
Bitter rot, *Gloeosporium rufomaculans* (Berk.) Thum.

RASPBERRY (*Rubus idaeus* L.).
Leaf spot, *Septoria rubi* Wint.

RICE (*Oryza sativa* L.).
Blast, *Piricularia grisea* Cke.

ROSE (*Rosa* sp.).
Mildew, *Sphaerotheca pannosa* (Wallr.) Lev.
Black spot, *Actinonema Rosae* (Lib.) Fr.
Leaf spot, *Cercospora rosicola* Pass.
Crown gall, *Bacterium tumefaciens* E. F. Sm. and Towns.

RYE (*Secale cereale* L.).
Stem rust, *Puccinia graminis* Pers.
Leaf rust, *Puccinia dispersa* Eriks. and Henn.
On inflorescence, *Cerebella sorghi-vulgaris* Subram.

SESBANIA, Indigenous (*Sesbania* sp.).
On broken branches, *Poria* sp.

SIMSIM (*Sesamum indicum* L.).
On leaf, *Cercospora sesami* Zimm.

SISAL (*Agave sisalana* Perr.).
Anthracnose, *Colletotrichum agaves* Cav. (apparently always a wound parasite only).
Leaf blotch, various types, all physiological; one, at least, due to heat injury.
From diseased leaf bases, *Pythium aphanidermatum* (Eds.) Fitzpat.

SOLANUM, Indigenous (*Solanum* sp.).
Rust, *Aecidium solani-unguiculati* P. Henn.

STEPHANOROSSIA, Indigenous (*Stephanorossia* sp.).
On leaves, *Mycosphaerella Stephanorossiae* Duke.

STRAWBERRY (*Fragaria* sp.).
Root disease, *Rhizoctonia solani* Kuehn.
Leaf spot, *Mycosphaerella Fragariae* (Tull.) Lindau.

SUDAN GRASS (*Sorghum sudanense* Stapf.).
Grain smut, *Sphacelotheca sorghi* (Lk.) Clinton.

SUGAR CANE (*Saccharum officinarum* L.).
Ring spot, *Leptosphaeria sacchari* van Breda.
Red stripe disease, *Phytomonas rubrilineans* Lee *et al.*
Leaf blotch, physiological.
Mosaic disease, virus.
Streak disease, virus.

TEA (*Thea sinensis* L.).
Brown blight, *Colletotrichum Camelliae* Massee.
Root disease, splitting disease, believed due to *Armillaria mellea* (Vahl.) Fr., but fructification not seen.
Scab, physiological.

THYLACHIUM, Indigenous (*T. africanum* Lour.).
On leaves, *Asterostomella africana* Syd.

TOBACCO (*Nicotiana Tabacum* L.).
Leaf spot, *Cercospora Nicotianae* Ell. and Ev.
Mildew, *Oidium Tabaci* Thuem.

TOMATO (*Lycopersicum esculentum* Mill.).
Leaf spot, *Septoria lycopersici* Speg.

TRAGIA, Indigenous (*Tragia* sp.).
On stem, *Phoma Euphorbiae* Sacc.

TRIASPIS, Indigenous (*T. auriculata* Radkl.).
Rust, *Puccinia haematites* Syd.

TURRAEA, Indigenous (*Turraea* sp.).
Rust, *Aecidium ugandense* Syd.

VIGNA, Indigenous (*V. vexillata* Benth.).
On leaves, *Woroninella dolichi* (Cke.) Syd.

WHEAT (*Triticum* spp.).
Black rust, *Puccinia graminis* Pers.
Yellow rust, *Puccinia glumarum* (Schm.) Erikss. and Henn.
Brown rust, *Puccinia triticina* Erikss.
Loose smut, *Ustilago tritici* (Pers.) Jens.
Red mould of ears, *Fusarium* sp. (? *F. culmorum* W. Sm.).
Glume blotch, *Septoria nodorum* Berk.
Black chaff, *Bacterium translucens* var. *undulosum* Smith, Jones and Reddy.
Seedling blight, root rot and scab, *Gibberella saubinetii* (Mont.) Sacc.
Take-all, *Ophiobolus graminis* Sacc.
Root rot, *Helminthosporium sativum* P. K. and B.
Leaf spot, *Septoria tritici* Desm.
Black mould, *Cladosporium herbarum* Link. (? true parasite).
From root, *Chaetomium globosum* Kze.

Essential Oils

II.—Oils from Indigenous Plants

By V. A. BECKLEY, *M.C., B.A. (Hons.) (Cape), M.A. (Cantab.), A.I.C., Senior Agricultural Chemist, Kenya.*

During the past six years a large number of scented indigenous plants have been distilled with varying success. Some have given oils in minute quantities, others oils which are of scientific interest only or which resemble well-known oils, while a few have given oils of real marketable value.

Among the plants in the first category may be mentioned *Tarchonanthus camphoratus* (*Mulileshwa*). The leaves of this plant are highly scented, rather unpleasantly, but on distillation only a trace of oil was obtained. It is possible that either the scent-carrying material is decomposed on distillation or it is water soluble. Another interesting plant in this group is *Artemisia arborescens,* known to the Somali as *Botrein,* and used by them extensively. On distillation a dark blue, very strong-smelling oil was obtained, but too small in amount to encourage further work. It appears that the dark blue colour is due to oxidation of some constituent of the oil.

Micromeria microphylla or *M. biflora* —there is some confusion in the identity of the plant—produces a fair yield of oil with a very fine verbena odour, and was most promising. The fresh oil contained over 60 per cent of citral. A few months later the oil was again analysed and found to contain only 16 per cent, while the odour has become musty. It is manifestly useless to produce so unstable an oil.

Another oil in the second class is that from the leaves of a species of *Zanthoxylum* (Lumbwa, *Sagawoita*). A fair yield of the oil was obtained on distillation, the odour was pleasant, and it appeared most promising. A sample was submitted to the Imperial Institute, where it was found that the main constituent was methyl-n-nonyl ketone. One firm to whom the oil was submitted doubted if any use could be found for it. Another pointed out that the main constituent was seldom used, and that it could be easily and cheaply produced synthetically. There is still a possibility of the oil being of some value.

Oil of Ocimum Canum.—The first oil of the marketable group is that of *Ocimum canum.* The plant is common around Nairobi on shallow soil liable to waterlogging, and is well known to the Kikuyu, their name being *M'kuri*. It is a shrub, 2 to 3 feet in height, with small rounded leaves about ½ in. in diameter, giving a camphoraceous smell when crushed. The flowers are white, and typically labiate in shape.

The plant gives a good yield of oil; as much as 0.6 per cent has been obtained, from which 16 to 25 per cent of true camphor can be obtained on cooling. *O. canum* has been grown on a commercial scale in the Colony, and both camphor and oil exported. On account of difficulty in maintaining the plantation, and the price of camphor, the production has now ceased.

The *Ocimums* are a most interesting group of plants, each species carrying a distinctive oil, and would repay further study. Owing to difficulties in cultivation this has not yet been possible. Only the oil from *O. nakurense* has been examined. It contains 15 per cent of eugenol, the main constituent of oil of cloves.

Muhugu Oil.—A very attractive oil, resembling vetivert, has been distilled from the wood of Muhugu (*Brachylaena hutchinsii*), yields varying from 0.6 to 0.9 per cent being obtained. The oil is rather difficult to distill, requiring protracted distillation; but, as the later fractions distilling contain the most valuable constituents, it is necessary to continue the distillation as far as practicable.

The oil is a pale viscous oil with a very strong vetivert note, but also somewhat resembling cedarwood oil. The opinion was expressed that there would be a demand for it in the fine perfumery trade; in fact, a small consignment of it was sold for about Sh. 20 per lb. During the past few years a small export has been developed in this oil. It has also been used experimentally for oil immersion lenses.

Oleo-resin from Excoecaria africana.—The scented wood of a small Euphorbiaceous tree was brought to the notice of the writer by the Kenya Forest Department. The wood is heavy and strongly scented, and resembles the South African *Tambuki* wood.

The first distillation gave a yield of 0.6 per cent of a very viscous, almost solid oil, which in the pure state had very little odour, but in dilute solution was strong smelling, the odour being very persistent. The difficulty experienced in the distillation of the oil, and the small yield obtained, led to the wood being extracted with petroleum ether. A yield of 10 per cent of a scented oleoresin was obtained, which was submitted to the Imperial Institute and to a firm of essential-oil merchants. The reports were discouraging, but recently references have been made in a trade journal to its value as a fixative in high-class perfumery. There is thus still a possibility of a market being developed for this material.

Oil of Cymbopogon afronardus.—In the Rift Valley, above Gilgil, there is a strongly scented grass, commonly known as lemon grass. A sample of this was distilled, and a yield of roughly 0.5 per cent of a clear yellow oil, resembling palmarosa oil, was obtained. Further lots of grass from Naivasha produced yields varying from 0.5 to just below 1.0 per cent. A sample was submitted to the Imperial Institute, which reports it as rich in geraniol. On a further larger sample sent, the report was to the effect that a good geraniol may be prepared from this oil, but that the demand would never be great.

The grass has been identified at Kew as *Cymbopogon afronardus*, but it appears there are several varieties of it. A lot of grass distilled at Kisumu gave traces of oil only, as compared with the 1 per cent from a sample of grass from Naivasha. Further, field observations made in many parts of the Colony show that the odour of the grass in some localities is very faint, while in others it is strong.

A small export has been developed in this oil, but it is not recommended that its production be entered upon by those who may have it growing on their farms. The demand is very small indeed, and any over-production will probably kill the development. In all such cases, where a new oil is being offered in competition with a similar well-established oil, production must proceed slowly, so that supply does not exceed the demand. Should a large supply be placed on the market, the oil, if of low value, will have to be sacrificed at a nominal figure to obviate storage charges, and probably the sale will result in a loss to the producer, and he will cease to produce the oil. Once an oil which is becoming established drops out of the market it is very difficult to re-establish it.

Virus Diseases of East African Plants
V.—Streak Disease of Maize

By H. H. STOREY, *M.A., Ph.D., Plant Pathologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

In the preceding article of this series the general characters of streak disease were considered in relation to those of other virus diseases affecting maize. In the present article I shall discuss in more detail the knowledge that has been gained of this serious and widespread disease.

THE SCIENTIFIC ASPECT.

Occurrence.—Streak disease was first recognized at the end of the last century as an important factor limiting maize production in Natal. Its cause remained obscure until, in 1925, work in Durban definitely attributed it to a virus (Storey, 1925). Since then the disease has been reported from many parts of Africa, even as far north as Egypt (Melchers, *in lit.*).

In East Africa, streak disease occurs probably in all areas where climatic conditions are suitable. It is prevalent, for instance, on the coastal plain and in Uganda (Hansford, *in lit.*); in the highlands it occurs infrequently, and is apparently rarely of economic importance.

Effects.—The most obvious consequence of infection by the streak virus is a severe chlorosis of newly formed leaf tissue, the chlorotic areas being elongated along the veins and separated by strips of normal green tissue, although adjacent chlorotic areas frequently fuse. The consequence is a characteristic and striking variegation (Fig. 1). Leaves that have matured before infection occurred show no change. In leaves formed soon after infection a few chlorotic spots and streaks occur; soon, however, the streaks become crowded, as shown in Fig. 1. At a later stage in the plant's growth the effects of the disease may diminish in severity, so that the new leaves bear streaks some-

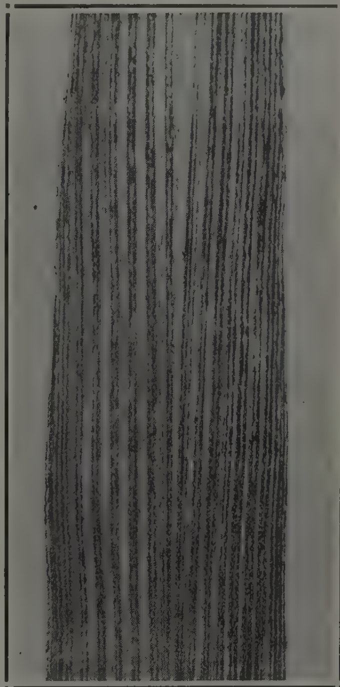

FIG. 1

what narrower and more widely distributed than those illustrated.

The secondary effects of the disease depend upon the age at which the plant became infected. If infected as a small seedling, it will remain severely stunted, and will probably set no seed. At the other extreme, a plant infected just before flowering will show no detectable ill-effects. The maize cobs shown in Fig. 2 illustrate the range of the ill-effects upon yield that may be anticipated from late

Fig. 2

and early infection. With the stunting of the shoot goes a corresponding stunting of the root growth, particularly in respect of the development of lateral rootlets. Typical examples of the main roots of diseased and healthy maize plants are illustrated in Fig. 3.

FIG. 3

Transmission.—Streak disease is not carried in the seed, nor can it be transmitted by any mechanical method of inoculation. The insect-vector, however, is an extremely efficient agent of inoculation, and the occurrence of the disease in the field can without doubt be attributed to its activity.

The most important vector is the leafhopper, *Cicadulina* (*Balclutha*) *mbila* Naude (Storey, 1925), a small, active insect, normally to be seen sitting in the cone formed by the emerging young leaf of a maize plant, and easily recognized at rest by its general slate-grey colour, interrupted by a median white stripe (Fig. 4). Recently two other vectors have been found in East Africa, *Cicadulina zeae* and *C. nicholsi*, similar to *C. mbila*, but lacking the characteristic white stripe.

These species of insects have been the subject of much study at Amani (*see* References). *C. mbila*, and probably the other two species, occurs in two races, able and unable respectively to transmit the virus. On emerging from the egg all

FIG. 4

insects are free from the virus. If of a suitable race, they may thereafter pick up the virus by feeding, for as short a time as a minute, upon a chlorotic area of a maize leaf, but not on the interven-

ing green area. They will not become infective at once, but only after a delay of a day or two. Once infective, they will infect every plant upon which they feed for a day or two, and often for an hour; and they may remain infective through several months before they die. They may infect a maize plant by feeding upon any above-ground part of it. The plant shows no effect at the point where the insect punctured, but only on the young leaves that emerge some days after the insect's feeding.

The distribution of *Cicadulina* spp. appears to be markedly controlled by climatic factors. Some information upon this point is available from the Amani district. The insects are most prevalent on the coastal plain; as the foothills of the Usambaras are ascended they diminish in frequency; while at Amani (3,000 ft.) they are extremely rare. *C. mbila* disappears first in this progression, whereas the other two species appear to tolerate better the higher altitudes. It is probable that the distribution of streak disease may, in part at least, be related to the distribution of the insect-vectors. Streak is severe on the plains, rather infrequent in the foothills, and absent from Amani.

The Range of Plants Affected.—In the last article, it was mentioned that a large number of species of the Gramineae may show symptoms resembling streak disease. They include several varieties of sugar cane and some twenty wild grasses (Storey, 1925, 1930). It is extremely doubtful, however, whether many of these plants may act as alternate hosts for the maize virus. This is because investigations have shown that each variety of plant tends to have a strain of the virus that is specialized to it, and either non-virulent or only weakly virulent to other species (Storey and McClean, 1930). It is certain that sugar cane cannot act as a host of the maize virus; some common weed grasses, particularly short-lived annuals, may probably so act, although others certainly cannot. On the whole, the part played by alternate host-plants in maintaining the maize streak virus seems to be a minor one.

The Practical Aspect.

Recognition.—The symptoms of streak disease in maize are so striking as at once to attract attention (Fig. 1). The nearly uniformly distributed, clear-cut pattern of yellow areas upon a normal green background should be looked for. This will be evident upon the youngest leaves of the plant; if the pattern is absent from these leaves, the plant is free from streak, even though markings on old leaves may be suggestive of the streak pattern.

The only difficulty in the recognition of this disease is the liability to confusion with a second virus disease called "Stripe". The yellow areas in this disease tend to be longer without a break than those of streak, and they may fuse together laterally to give broad, almost uniform yellow bands. The symptoms are very variable; the two types illustrated in Figs. 7 and 8 of the fourth article of this series (*E.A. Agric. Journal,* I, p. 336) are fairly readily distinguished from streak. Some types, however, come so close to streak that differentiation may be very uncertain even by one well acquainted with both diseases. In such instances, insect-transmission experiments can alone give a certain diagnosis.

Control.—Comparatively few of the usual means of virus disease control are available in this instance. No naturally immune varieties of maize are known, nor is there any likelihood that any kind of artificial immunization could be effective. No method of direct attack upon the insect-vector offers any prospect of success.

Owing, however, to the limited host-range of the streak virus, the attack upon the virus during its carry-over stage, between one crop and the next, has favourable prospects. On the Natal coast this worked effectively; for, if no maize was grown during the winter in a district, the early-planted summer crop usually escaped severe infection, even though I was able to prove that infective insects might survive the winter in small numbers. On the other hand, if a succession of maize crops was raised through the year, very few plants ever escaped infection at any season.

We thus see that the best line of control lies in the extension of the period between crops to its maximum length. The destruction of any volunteer plants that may grow after the crop is harvested—a point so often insisted upon in these articles—is important. The more nearly the sowings in a district are made at the same time, the less they should be subject to damage by streak. If a succession of sowings over a long period are made in a district, the conditions are ideal for a heavy infection of the later-sown crops.

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Whisk or Broom Corn

The fibrous material obtained from the pale yellow heads of *Sorghum bicolor* is known as "whisk" in the English brush manufacturing trade and as "broom corn" in the United States of America. A large brush manufacturer in England states that supplies are nearly all obtained from Italy where the crop is extensively grown throughout the Northern Italian Plain.

The best quality is known as Venetian whisk which is used in England for making carpet brooms and bannister brushes, dandy brushes and clothes brushes.

At the present time supplies from Italy are unobtainable owing to the enforcement of the sanctions and the Mexican and French whisks are used instead. These materials are much more expensive. They are somewhat finer and lighter in colour and are obtained from the fibrous roots of the grasses *Epicampes macroura* and *Chrysophagus gryllus* which flourish in swampy ground.

The Venetian whisk is sent to England cleaned and dressed ready for use. It is sent over in two packings. One is in the form of long tops, about 10½ inches long, made up in bundles of about 2½ inches diameter which are fastened in 90 lb. bales; this material is priced at about 7¼d. per lb. c.i.f. London plus an import duty of 10 per cent to which, however, the colonial product is not subject. The other pack is 19 inches to 24 inches long in 7 lb. bundles which are made up in bales of 65 to 70 lb. weight; in this case the fibre is valued at 9d. per lb. c.i.f. London plus the 10 per cent import duty.

This crop has been grown in various parts of the Empire and it would appear worth testing as to its economic possibilities in East Africa. It is understood that the extent of the trade in this fibre is quite considerable but more definite information on the point is being obtained from England.

This *Sorghum* was grown successfully last year by a farmer near Nakuru who observed: " . . . The heads we grew this year weigh 25 per lb. . . . 10,000 plants per acre . . . we would state that these heads were grown without any knowledge or system and possibly are light . . ."

The Ecology of Coffee Plantations

Climatic Conditions in East African Coffee Plantations

By T. W. KIRKPATRICK, *M.A., Dip. Agric., F.R.E.S., Entomologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

The literal meaning of the word "ecology" is "the study of houses". It is, however, not used as a synonym for architecture, but for "that branch of biology which deals with the relations of animals and plants to their surroundings, their habits and modes of life, etc." The above definition is that given by the Smaller Oxford English Dictionary, but I have also heard of two other definitions which are of interest. One is that ecology is "scientific natural history", which is self-explanatory, and, for a simple definition, could hardly be bettered. The other is that ecology consists of "saying what everybody knows in language which nobody understands." Unfortunately, this contains far too much truth. It is people who write papers in which a garden is described as a "hemerecological biome", or some such nonsense, who make scientists shudder and laymen laugh. Technical terms are unavoidable in any science, as without them precision and accuracy of meaning are unobtainable, but there are no excuses for jargon. It is hoped that the following short account of work that has been done on the local climates of coffee plantations in East Africa will show that much of the information obtained is not only "what everybody knows" but in many directions not what anyone—however well acquainted with coffee plantations—could have guessed by the light of nature and without making numerous observations with accurate instruments. It is also believed that it is possible to present at least a summary of the more important results obtained in ordinary straightforward language. It is, of course, true that anyone who is sufficiently interested in the subject to wish to understand the physical principles involved, or to analyse and criticize the data on which the results briefly presented here were based, must consult the original paper.* This, though I believe it is free from jargon, is not, and could not be, free from technical terms.

The first essential step towards the further study of the ecology of coffee plantations appeared to be an investigation of the local climates occurring in and around the coffee bushes, in the actual situations in which the insects associated with the coffee plant live. Such local climates are known as "eco-climates", i.e. the climates of actual environments. It is clear that they may vary very greatly from the ordinary or "standard" climate of the district, as measured by the standardized methods of the meteorologist.

The important meteorological elements which determine the climatic conditions of an environment are Temperature, Moisture, Light and Wind. (The pressure of the atmosphere, as measured by the barometer, is probably also of importance in temperate latitudes, but in the tropics the daily and annual variation in pressure at any one altitude is so slight that it is hardly possible that it can have any significance.)

Some little explanation of these four factors is required, as the first three at least are not quite so simple as they sound.

* Kirkpatrick, T. W.: "The Climate and Eco-climates of Coffee Plantations," *Amani Memoirs*, 1935.

The temperature of a body (unless, like a warm-blooded animal, it has a source of heat supply of its own) is dependent both on the temperature of the medium which surrounds it, and, if such be present, on any radiant heat which may fall on it. The latter depends on the capacity of the body concerned for absorbing radiation. One often hears, on a hot day, someone express surprise that the temperature is "only 85°," and exclaim, "but I expect it is 120° or more in the sun." The truth is there is no such thing as "temperature in the sun". With suitable precautions, we can measure accurately the temperature of the air, and whether that air is in the shade or in the sun makes no difference. We can also measure the temperature of any object exposed to the sun, but what its temperature will be depends on the nature of the object, and on other factors, such as wind and movement. Which is why a (human) body dressed in black clothes is warmer on a sunny day than one dressed in white, while on a windy day both will feel less heat from the sun than they would on a calm one, as the radiant heat absorbed is more quickly dissipated.

The Humidity of the air can be described in three ways. The Absolute Humidity is the actual amount of water, in the form of vapour, in a given quantity of air. This might seem to be the most obvious way of measuring it, but for biological purposes it is certainly the least useful. For the amount of water vapour that any given quantity of air can contain, without its becoming saturated and depositing its surplus in the form of rain or dew, depends on the temperature. The warmer it is, the greater is the amount of water vapour that air can contain. Thus the same quantity of air, say a cubic yard, may actually contain more water on a hot "dry" day in a tropical country than on a cold "damp" day of an English winter. This brings us to the second and most usual method of measuring humidity, that of Relative Humidity, or the percentage of the total possible quantity of water vapour which a given sample of air, at the temperature it happens to be, could contain. This is, at least to our own personal feelings, a more sensible (in both meanings of the word) method of measurement, for we feel uncomfortable when the relative humidity is high, whether it is the "muggy" heat of the tropics or the "raw" cold of more northern latitudes. Whereas at least up to a point the dry heat of a desert climate, or the crisp cold of an Alpine one, feels invigorating.

It will now be clear that if a quantity of air is cooled, its relative humidity will rise, and if it is cooled below "saturation point", i.e. below the temperature at which its relative humidity is 100 per cent, then some of its water vapour will condense in the form of rain or dew.

But there is a third measure of measuring humidity, scarcely used at all by meteorologists, and only just beginning to be used by biologists. This is known as "Saturation Deficiency", and is a measure of the amount by which air of a given temperature falls short of being saturated. This is usually measured in terms of pressure of water vapour, either in millibars or millimetres of mercury (as in a barometer measuring the pressure of the air), though it could be just as well measured in grammes to the cubic metre or grains to the cubic yard.

Thus a cubic yard of air at a temperature of 80° F. and a relative humidity of 75 per cent would contain approximately 222 grains of water in the form of vapour; it is therefore short by 25 per cent, or 74 grains, of the water it could contain if it were saturated, which is 296

grains. Another cubic yard of air might have a relative humidity of 60 per cent, and therefore in one sense be drier than the former, but if its temperature were 50° F. it could only contain 110 grains of water vapour if it were saturated; as its relative humidity is 60 per cent, it actually contains 66 grains, and its saturation deficiency is therefore 110 − 66 grains, or 44 grains, which is less than that of the sample first considered. In this sense, therefore, it is damper, as it would require the addition of less moisture to render it saturated.

The reason for regarding saturation deficiency as the best method of estimating humidity, at least for some biological purposes, is that the loss of water by evaporation from a free water surface, and, in many cases, though with less precision, from the body of an insect, is directly proportionate to the saturation deficiency, provided that other factors are equal. Other factors are not, however, necessarily equal, and this brings us to a consideration of the subject of evaporation.

The rate of evaporation of water is determined by a complex of four factors. It is increased with a high temperature and decreased with a high (relative) humidity, or, as has been said, it increases with the saturation deficiency, which takes into account both temperature and relative humidity. It is also increased according to the velocity of the wind, and according to the rarity of the air (low barometric pressure) which, for our purposes in the tropics, may be considered as depending only on the altitude above sea-level.

The importance of the evaporation rate in the economy of an animal is partly that when the rate is high, more liquid must be consumed to replace what is lost, and partly owing to the cooling effect of evaporation on the body. This latter can only have much effect on comparatively large-bodied animals, and in the case of the smaller insects can be of little or no importance.

Besides the humidity of the air or of the soil, the other aspect of moisture as a climatic factor is its precipitation, either in the form of rain or mist (and, in some countries, hail and snow) or as dew. It must be noted that it is quite possible for it to rain when the relative humidity at ground level is well below 100 per cent, for the rain has been formed by the cooling of the air, and consequent condensation of water-vapour, at a higher level. Similarly, dew will form on any object the temperature of which is below the "dew point" (i.e. the temperature at which the air of a given relative humidity would, if cooled, become saturated) even if the surrounding air has a relative humidity of less than 100 per cent. The formation of dew on the outside of a glass containing an iced drink, on all but the driest days, illustrates this.

The third meteorological element, Light, is the most difficult to measure and the least understood, at least in its effects on animals, if not on plants as well. Not only the total intensity of light which penetrates to an environment, but also the quality (wave-length) is almost certainly of importance. Very little information exists on this subject, and it will scarcely be mentioned in this brief account.

The fourth element, Wind, is perhaps the simplest to understand. The direct effects of strong winds, both on plants and animals, are sufficiently obvious. It must also be remembered that air movement, besides increasing evaporation, as has already been mentioned, mixes up different layers and pockets of air, thus tending to equalize conditions and to

avoid extremes of temperature and humidity.

Such then, at least for simple and practical purposes, are the factors which determine the meteorological conditions of an environment. A wood-boring beetle is affected by temperature, but not by light, wind or humidity; an insect living deep in the soil by temperature and humidity, but not by light or wind; an aquatic animal by light and temperature only, unless it lives near the surface of the water, when wind may indirectly affect it. And so on with any combination; temperature is the only factor always present and variable, though even this is not strictly true, as there are animals living deep in caves where the temperature is constant throughout the year.

Now let us very briefly consider the rapid rate at which insects, whether pests or not, tend to increase in numbers, and the factors which limit their increase.

A single adult of the common coffee mealy bug of Kenya would, given suitable climatic conditions, an absence of all natural enemies, and the (impossible) condition that enough food was available, have produced by the end of the year about forty thousand million *tons* of mealy-bugs.*

This is an extreme case of an insect with short generations and a high "birth-rate", but even a bug like *Antestia*, which is comparatively slow-growing as tropical insects go, is theoretically capable of an amazingly rapid increase. Thus a single *Antestia* egg laid on the 1st of January (provided that it developed into a female, and that it and all its female offspring were fertilized) would, in the absence of all controlling factors except normal old age, have produced over eight million bugs by the end of the year.

Three factors set a limit to these fantastic rates of increase. The most obvious is the lack of food—if there were no other causes of mortality, every species of animal (including man, almost the slowest of all to increase) would soon have consumed all its available food, and would therefore cease to exist.

Although in many ways (often indirect ones, such as the difficulty an animal experiences in finding its food, even though the food exists) the food question is the most important limiting factor, it is of little consolation to the farmer to know that a pest will disappear as soon as it has almost completely destroyed his crop.

The second factor is the destruction caused by "natural enemies"—predators (e.g. lions on man and ladybirds on mealy bugs), parasites (e.g. malaria in man and small wasps in the eggs of *Antestia*), and diseases. Roughly, under this head could be classed what we call "accidents", such as crashing in an aeroplane or slipping on a banana-skin; but although accidents play a considerable part in augmenting the premature mortality of man, and to a lesser extent of his domestic animals, it is probable that they are of quite insignificant importance among "wild" animals.

And the third factor limiting populations is the one with which we are concerned here, namely climate.

* If you do not believe this, work it out. The following data are sufficiently accurate, and it will simplify the sum if round numbers are used: (*a*) One mealy bug weighs one milligram (the one-millionth part of a kilogram); (*b*) A mealy bug becomes adult and produces young in forty days; (*c*) One adult will produce one hundred and fifty young. Logarithm tables will help with this sum.

There is a considerable divergence of opinion, which cannot be discussed here, as to the relative value of natural enemies and climate as agents of control. The fact of the matter is that, apart from a few well-studied cases in which it is known that one, or the other, is of paramount importance, the two are interdependent. It must, however, be noted that it does not necessarily follow that any species increases most rapidly under what are actually the optimum climatic conditions for it. It may be that such conditions are also favourable for its natural enemies, and consequently it is held in check; whereas conditions far removed from the optimum might be so adverse for its enemies that they could scarcely exercise any control, and the species would then increase.

The effect of climate on the abundance of a species can be considered under two aspects, which might be called catastrophic and cumulative. The former is for the most part caused by weather and the latter by climate.*

Instances of catastrophic causes are: unusual cold or heat, excessive rain or drought, and, in some cases, thunderstorms or gales, any of which may have a considerable effect on the numbers of an animal.

But it is almost certain that the cumulative effect of quite trivial differences in climate have in the long run a much greater significance. Thus, to take one hypothetical case, quoted from my original paper: "Consider the case of a parthenogenetic insect such as a mealy bug, that in one habitat lays 100 eggs and requires 36 days for its complete life-cycle. If the average daily mortality from all causes is $12\frac{1}{3}$ per cent of those still surviving, the population will remain stationary. If, however, in another habitat, the average number of eggs laid is increased by 5 to 105, and the time required for the life-cycle reduced by one day to 35 days, even if the mortality remains the same, viz. $12\frac{1}{3}$ per cent per day, each generation will increase in numbers by 20 per cent, and after ten generations, i.e. in less than a year, the population will have multiplied itself six-fold. From such scanty data as are available it would appear certain that—at least with many species of insects—the variations in eco-climatic conditions required to produce differential rates of increase such as those in the above two examples are very much less than the variations that may in fact be found in two habitats only a few yards apart."

At this point, if he has got so far, I seem to hear the practical coffee planter say, "All very interesting" (or, perhaps, "How appallingly dull!") "but what on earth is the use of it? Weather and climate are with us for good or ill—usually the latter—and though no doubt you could tell us that the climatic conditions in certain areas are unsuitable for coffee-growing, we have got our *shambas* established, and we must put up with the climate we have got." That is precisely what the coffee-planter need not do. Within limits certainly, but not within such narrow limits as might be expected, he can condition (*pace* Mr. A. P. Herbert's "Word War" in *Punch*) the climate of his plantation in the same way that he conditions the eco-climate in which

* The difference between weather and climate is mainly one of time. Weather can be defined as the condition of a given place at a given moment, in so far as it is determined by the meteorological elements. The climate of that place is the resultant of the weather experienced over a considerable period—a year or more. Thus one can speak of "the climate of Mombasa" but of "the weather at Mombasa on the 1st of January".

he himself lives when indoors; that is, quite literally, the climate of his house.

As regards what I have called the "catastrophic" effects of weather, it is true that comparatively little can be done, though a certain amount of control is already, perhaps without consciously thinking of it as control of weather, in common practice. Obvious instances are windbreaks in districts where prevailing strong winds are liable to be harmful, and contour-trenching and other methods of securing drainage and preventing soil erosion in areas where excessive rainfall may be experienced.

But it is with the possibility of altering the "cumulative" effects of climate that the investigations, briefly described here, are concerned.

The first step was to ascertain to what extent the meteorological conditions differ in a typically fully grown coffee plantation, unshaded, and on level ground, from the conditions recorded in an adjacent "standard" meteorological station, i.e. situated over short grass on level ground; temperature, humidity, and evaporation being measured in a Stevenson screen, the wind velocity in a fully exposed situation at a height of two metres, and soil temperatures and rainfall in exposed, unsheltered positions.

The following is a very much abbreviated summary of the results obtained:

Temperature of the Air.—During the day, between 9 a.m. and 4 p.m., higher in the plantation than in the screen. The difference may be as much as 8° F. on clear, sunny days, about or shortly before noon; it is much less on overcast days, and when the bushes are wet with rain from a recent shower it may be cooler in the plantation than outside. Between about 5 p.m. and 7 a.m., the plantation is cooler than the standard temperature; the difference is similarly greater on cloudless nights, when it is sometimes as much as 5° F. Thus, on a day when the maximum and minimum temperatures recorded in the screen have been, say, 80° F. and 55° F. respectively, in a thick, well-grown coffee bush they will have been about 85° F. and 52° F. It should be noted that the maximum temperature occurs an hour or more earlier in the plantation than outside, hence the difference in the total daily range of temperature, though it may often be as much or more than 8° F. greater in a coffee bush, is not so large as one would expect from comparing the temperatures about noon, when that in the plantation is at about its maximum, whereas that outside will continue to rise for some time.

Humidity.—The saturation deficiency and usually, but not necessarily, the relative humidity roughly follows the temperature. That is to say, when it is warmer in a coffee bush than in the screen, it will usually be drier, and vice versa.

The difference in relative humidity at a given moment may be surprisingly large; thus one instance was recorded, about dawn on a clear day, when the relative humidity was 56 per cent in the open, but 93 per cent inside the plantation. On overcast days, though the plantation will, as has been said, be somewhat warmer, it is likely also to be a little damper than outside.

Evaporation.—Only about midday on the hottest and driest days does the increased temperature and lower humidity in a coffee bush compensate for the reduced wind, hence

the evaporation is on the whole much lower in a plantation than in the screen.

Wind.—The air movement between the bushes of a coffee plantation will vary from about 40 per cent (of light winds) to 60 per cent (of stronger winds) of that in the open. In the interior of a thick bush it will only be at most 6 per cent of the strongest normal winds outside, whereas when there are only gentle or moderate breezes scarcely any air movement can be observed within a bush.

Light.—The proportion of light penetrating a thick coffee bush is naturally much reduced, and may be scarcely more than 1 per cent of that measured in the open.

Rainfall.—The actual amount of rain that falls on a coffee plantation is of course the same as that which would fall if no plantation were there, but the amount reaching the ground at any one spot may vary from 0 per cent to at least 400 per cent of the total, according to the position of the measuring gauge in relation to the bushes, and to the quantity and heaviness of the rain.

Not all insects connected with coffee (or any other crop) are free-living; many live in restricted habitats, such as leaf-miners, the larvæ of which inhabit a tunnel between the two surfaces of a leaf, or wood-boring beetles living in the trunk or branches. And a very large number of insects live in the soil. When we consider habitats such as these, far greater divergences from the "standard" climate are to be found. Thus, the temperature inside a mine in a coffee leaf, inhabited by a living larva of the coffee leaf-miner, and exposed to the sun, was found to reach about 113° F. at midday, or some 27° above the air temperature in the bush at the same time. Such high temperatures do not, however, last long, as they are rapidly lowered by quite slight breezes. Such mines in exposed leaves also fall at night to a lower temperature than the surrounding air, and it is safe to say that on an ordinary January day in Kenya the larva of one species of the coffee leaf-miner may be subjected to temperatures ranging between 48° F. and 113° F.

It is of interest to note that two species of coffee leaf-miner occur in East Africa, one of which lives in habitats exposed to extreme ranges of temperature, like that just mentioned, while the other species is almost entirely confined to leaves which, owing to their position inside the bush, or to the incidence of heavy shade on the bush, or to other factors producing the same effect, are subjected to a much smaller temperature range.

On the other hand, an insect such as the larva of a wood-boring beetle, living in the trunk of a coffee bush, experiences a range of temperature not only less than that of the air in the plantation, but less than that of the "standard" by some 5° F. or thereabouts.

Insects living in the soil of a coffee plantation have at their disposal a very wide range of temperatures, according to the depth at which they live and the position in relation to the bushes. Thus the temperature on the surface of bare soil between the rows of coffee bushes may vary from a maximum of 160° F. to a minimum of 50° F. in twenty-four hours. (It is of interest that this maximum is often higher than that of similar soil completely exposed in the open, owing to there being less wind movement, and therefore less cooling effect, among the bushes, in spite of the fact that the soil in a plantation receives the direct

rays of the sun for a shorter period.) At a depth of just under half an inch the range of temperature is reduced to about 77° F., and at six inches it is only about 9° F., as compared with over 100° F. on the surface. Underneath a thick bush, where no direct sunlight penetrates, the temperature at a depth of half an inch only varies about 19° F., and at two inches about 10° F.

It is clear from the foregoing short account that the climatic conditions in and around coffee bushes are widely different from the "standard"; that is, the conditions which would exist if there were an open space instead of a coffee plantation. There is, however, a very fair measure of correlation between the two, and from a knowledge of the standard climate of a district it is possible to deduce with a fair approach to accuracy what the conditions in a given habitat in a coffee plantation will be during any usual type of weather.

Not all coffee plantations are close-spaced, with thick foliage, unshaded and on level ground. There are a number of factors which may cause the climatic conditions to vary very considerably from those in a plantation of the type hitherto described. The most important of these factors are: the configuration of the ground, the spacing of the bushes, recent pruning, shade, windbreaks, and, in a wide-spaced plantation, cover crops and dry grass mulches. With the exception of the first, it will be noted that all of these factors are, to some extent at least, under the control of the planter.

Table I (taken with slight simplifications from my original paper, which must be consulted for details) shows the direction in which these factors alter the climate from that which would be expected in a close-spaced, unshaded plantation on level ground.

A few more of the outstanding details may, however, be given here. A depression in the ground, or a valley between two ridges, occasions greater extremes of temperature than are to be found elsewhere. Thus a temperature of 94° F. has been recorded in a bush in such a depression, at a time when the temperature in a bush on level ground was 88½° F., and the standard screen temperature only 84° F. Over a period of 15 days the average difference in air temperature at the bottom of this hollow was, for the maximum, 4° F. higher than in the plantation on the level, and over 8° F. higher than in the screen; for the minimum, 6° F. and nearly 9° F. lower respectively. The lowest temperature on the top of an unshaded bush in a hollow may certainly sometimes be as much as 12° F. lower than that in the screen; thus it is quite possible that a frost might occur locally on a night when according to the ordinary meteorological reckoning the temperature had not fallen below 44° F. Windbreaks have a somewhat similar effect to hollows in the ground on the range of temperature.

Wide spacing of the bushes and heavy pruning both tend to reduce the difference between the conditions in the plantation and in the screen.

It is common knowledge that shade tends to equalize the temperature, reducing the maximum and increasing the minimum; but the extent to which it does so is probably hardly realized. Fig. 1 shows the average difference in temperature in a coffee bush under *Albizzia* shade from that in a nearby unshaded bush, over a period of eight weeks during the warm season—February and March. It is of interest that with clear days and nights the average temperature for the 24 hours is higher under shade than outside, as the increased temperature from about 6 p.m. to 8 a.m. more

TABLE I

How Certain Factors Alter the Climate from that to be Expected in a Close-Spaced Unshaded Coffee Plantation on Exposed Level Ground

ON	The Effect of the Undermentioned Modifying Factors								
	Easterly Slopes 1	Westerly Slopes 2	Valleys and Hollows 3	Heavy Pruning 4	Shade 5	Windbreaks 6	Wide-spaced Bushes With: Bare Soil 7	Cover Crops 8	Mulches 9
Air Temperature:									
Morning	++	−	++	−	−−−	+	−	+	+
Afternoon ..	−	++	++	−	−−	++	−	+	+
Night	×	×	−−−	+	++	−	+	−	×
Soil Temperature:									
Morning	++	−−	+	++	−−−	+	+++	−−−	−−−
Afternoon ..	−−	++	+	++	−−−	+	+++	−−−	−−−
Night	×	×	−	×	+	×	−	+	++
Temperature of Trunk of Bush (by Day)	×	×	+	++	−	+	++	×	×
Temperature of Leaves of Bush:									
Day	×	×	+	−	−−−	+	−	×	×
Night	×	×	−	×	++	−	×	×	×
Relative Humidity of the Air:									
Morning ..	−	+	−	×	+++	×	×	++	−
Afternoon ..	+	−	−	×	++	−	×	++	−
Night	×	×	+	×	−	×	×	+	×
Humidity of the Soil	+	−	×	−	++	+	−	++	+++
Wind Movement ..	+	−	−	++	−	−−−	++	−	×
Evaporation ..	×	×	×	++	−−	−	++	−−	+
Penetration of Daylight	×	×	×	+++	−−−	×	+	×	×

Explanation :—

+ = Slightly. ++ = Moderately. +++ = Very considerably greater.

− = Slightly. −− = Moderately. −−− = Very considerably less.

× = No appreciable effect.

Columns 8 and 9 are in comparison with column 7, which must be added to either to show the approximate difference between a wide-spaced plantation with a cover-crop or mulch, and a close-spaced plantation.

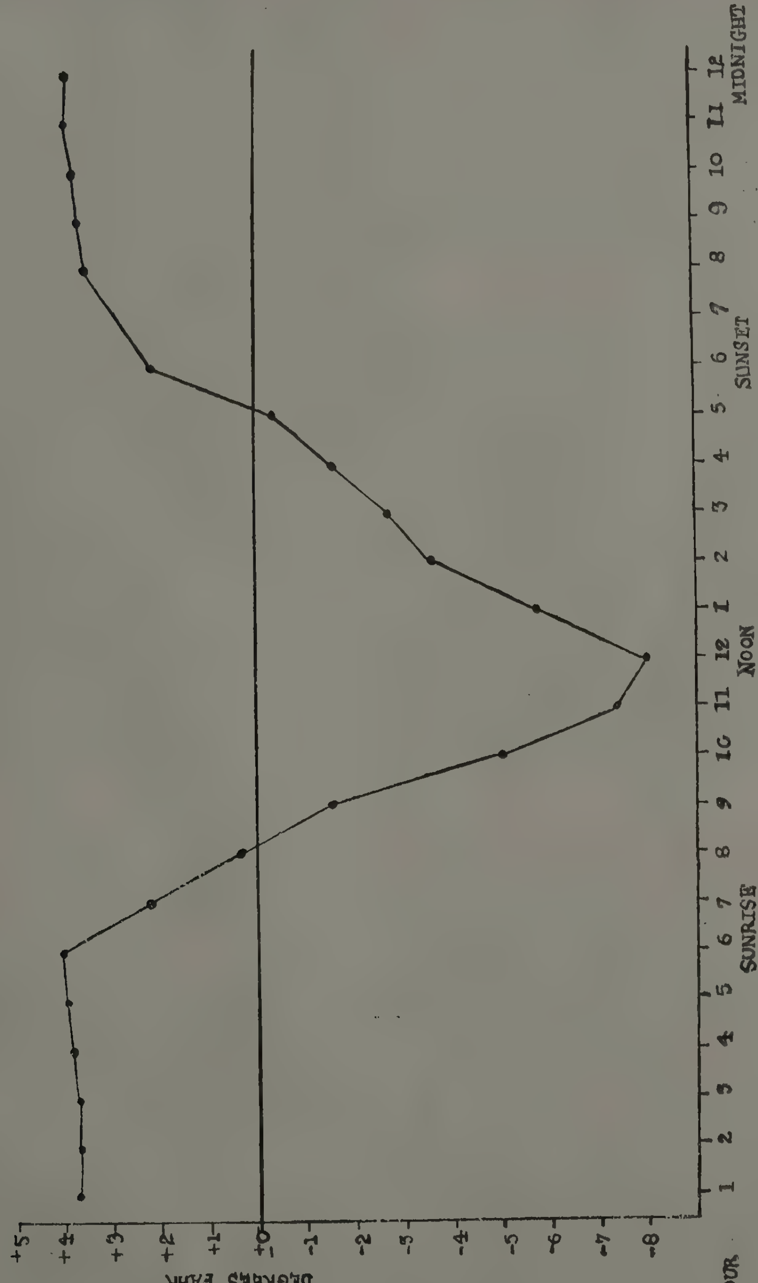


Fig. 1

The average difference in Air Temperature in a coffee bush under *Albizzia* shade from that in a near-by unshaded bush, over a period of eight weeks during the warm season (February and March).

than compensates for the shorter period in the middle of the day, when the unshaded bush is considerably warmer. But if both days and nights are overcast the average temperature under shade is lower than that outside, as during the day the unshaded bush warms up appreciably more owing to radiation from the clouds, while at night there is little or no difference.

It should be noted that the foregoing refers to a "canopy" shade; tall and almost unbranching trees of *Grevillea robusta* at rather wide intervals, which are one of the commonest forms of shade in East Africa, produce a much smaller equalizing effect. Indeed, as they give most shade during the early morning and late afternoon, and but little protection at midday and by night, when protection is most needed, they are of very little use as equalizers, and may even tend to have the accentuating effect on temperature range that is produced by windbreaks.

It will be observed from Table 1 that in a wide-spaced plantation, if the ground between the bushes is planted with a cover crop, or covered with grass mulch, the effect is in many respects to make the climate conditions approximate to those of a close-spaced plantation. The most important difference is that both a cover crop and a mulch increase the humidity of the soil, but whereas the former also increases the humidity of the air (and consequently lowers the evaporation rate), the latter actually causes the air above it to be of a lower humidity than it would be over bare soil.

It is true that practical application to the control of insect pests of the knowledge so far gained on the climatic conditions in coffee plantations is in many cases at present impossible. This is largely due to our existing ignorance as to what exactly are the optimum conditions for the majority of insects. It is, however, suggested that it is no longer accurate for anyone, whether planter or entomologist, to say, "The causes of such-and-such an outbreak are climatic, and therefore nothing can ever be done about it."

Pruning Coffee Trees*

By B. R. Iglesias.

Before describing the system of pruning which has been practised for three years running on the coffee plots at the Experimental Station of this Centre (a system which has given very satisfactory results, and which we therefore wish were understood and practised in this country), it is convenient, for the sake of clarity, to give a few lines to describing the development of the coffee tree and to consider the principles which are to be followed in the practice of pruning.

The coffee tree may be considered as consisting of two parts: a subterranean one which bears the organs of absorption known as roots, and a second, bearing those organs whose main function is the manufacture of the food supplies of the plant, which is called the stem.

Pruning is practised on the stem, and we are therefore concerned with its development.

The stem of the coffee tree grows vertically, becoming thinner and thinner until it terminates in a bud which is found at the junction of two opposite leaves and is protected by two membranous structures called stipules, which are formed at the base of the leaf stalks. The stipules protect the bud by means of their covering of waxy substance. The development of the terminal bud results in the indefinite prolongation of the stem, unless it is for any reason arrested.

Fig. 1

As the bud develops, the stipules separate, and two small leaves appear, of a yellow-bronze colour, which later become green. These two small leaves are attached to a node of the shoot. The internode below this point increases in length and this lengthening is continued above the leaves.

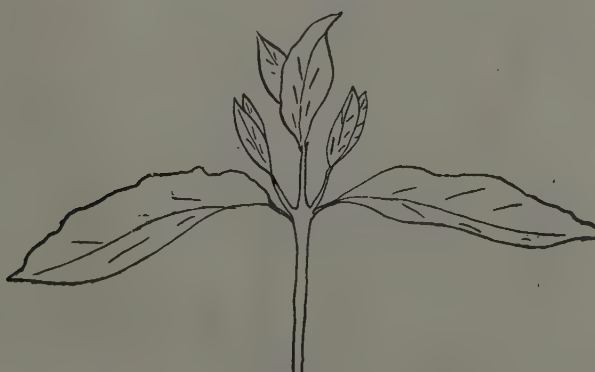


Fig. 2

Accompanying the terminal bud and covered by the same pair of stipules are two lateral buds, which give rise to the

* From *Revista del Instituto de Defensa del Cafe de Costa Rica*, Vol. I, No. 4 (1935).

primary branches, commonly known as *bandolas* (Figs. 1 and 2). The primary always grows from the angle of a leaf with the main stem, and its growth depends on the development of the terminal bud. In its earliest stage of development, the primary makes an angle of some 15° to 20° with the main stem, but, as it grows, the angle becomes wider and wider, until it lies in a nearly horizontal position. The first lateral buds, those which are formed in the axils of perhaps the first five pairs of leaves of the young coffee plant, do not develop unless the terminal bud has been destroyed below the fifth node, in which case they always take a vertical position and function as secondary shoots which will later produce secondary branches. Since in this case the shoots have sprung from the axils of the leaves, they form at the point of junction an acute angle, which makes them easily distinguishable from secondary shoots formed by the development of adventitious buds.

The primary branch has at its tip a terminal bud, together with two tiny lateral buds which may or may not develop (Fig. 3).

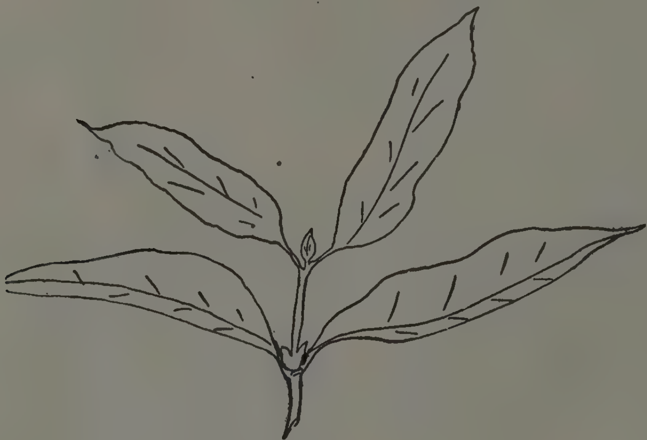


Fig. 3

The terminal bud is the one which increases the length of the branch; but if for any reason this bud is destroyed, then the lateral buds come into play, forming secondary branches or *palmillas*, which, in their turn, should the terminal bud be destroyed, may form tertiary branches.

The ramification of the primary branch may occur without the elimination of the terminal bud if the plant encounters particularly favourable conditions for its vegetative growth (Fig. 4). In some cases it has been observed that adverse conditions may produce the same effect.

If the terminal bud of the main stem be destroyed at about the fifth node, above a pair of already formed primary branches, or if for any other reason the flow of sap in the upward direction is interrupted, secondary shoots appear, growing from adventitious buds which are formed below the junction of the secondary branches with the stem. These new shoots are generally formed in pairs at the last node of the stem. If the last

two primary branches are cut away, these shoots develop rapidly, otherwise the sap goes on nourishing the primary branches

Fig. 4

and consequently the appearance of the shoots is retarded.

Under certain circumstances—for instance, after a heavy crop—if circumstances have not been sufficiently favourable to allow of the development of new wood at the same time as the production of fruit, the main stem, as well as the secondaries if there are such, will become covered for nearly the whole of their length with adventitious shoots or *hijos* (literally "sons"), one, two, or more at each node. The same phenomenon is seen when the shoots are bent, whether accidentally or by the weight of the fruit, in which case the adventitious shoots are formed only on one side of the shoot.

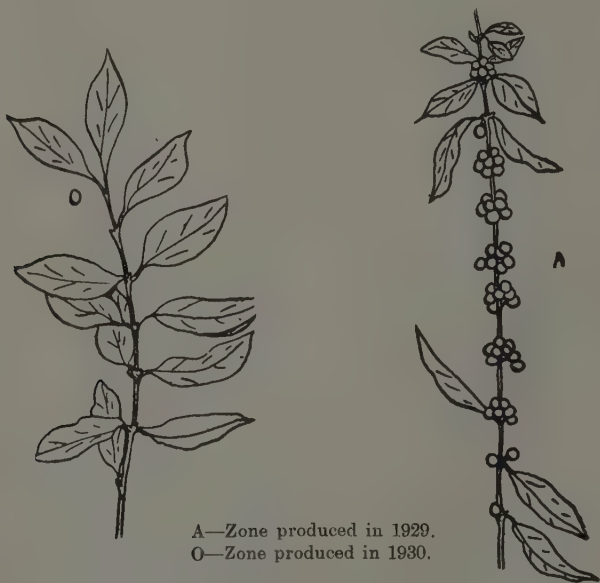
The primary branches of the coffee tree are arranged in a phyllotaxic order of three-six; that is to say that if, starting at the junction of one of the branches, a line be drawn parallel to the main stem until the junction of another branch be reached, there will be five intermediary branches in a spiral around the stem.

The branches serve to support the leaves, which in the coffee tree are borne in pairs above the nodes and in two different planes, perpendicular to one another. This peculiarity can only be seen by observing the arrangement of the new leaves at the tip of the branch, because as this develops it undergoes a twisting movement which brings all the leaves into the same plane, so that they shall have equal access to the sunlight. Careful observation of the herbaceous part of the branch reveals a longitudinal spiral groove which indicates the twisting which the branch has undergone in the course of its development.

When the coffee tree is subjected to changes of temperature and of precipitation, growth of the branches is not uniform but corresponds to changes in conditions. At the beginning of spring the plant enters upon intense vegetative activity, which is shown in the rapid prolongation of the branch, continuing until the exigencies of nourishment for the fruit divert, to a certain extent, the flow of the sap. The ripening of the fruit, followed on the Pacific side of the country by a pronounced drought and by a fall in temperature, causes an almost complete suspension of vegetative activity, which is seen in the small number of leaves, small also in size, produced during this period. As the branch lengthens, increasing the distance of the terminal bud from the main axis, the zone which represents the period of vegetative activity is correspondingly smaller.

It may be said that the increase in length of the branch during this season of

activity will always be approximately half the growth of the previous year; that is to say, if the branch has grown 50 centimetres in its first year of development, in the second it will reach a total length of 75 centimetres, and in the third barely 87.5 (Fig. 5). As the fruit of the coffee is only produced along the wood of the previous year, this relationship between the age and the length of the zone of production of the branch must be carefully considered in the practice of pruning.



A—Zone produced in 1929.
O—Zone produced in 1930.

Fig. 5

When the principal axis of the coffee tree develops freely, the tendency is for the sap to nourish chiefly the main bud and the new branches, so that the lower primary branches gradually weaken, and die after two or three crops. The loss of these primaries means a reduction in the productive capacity of the plant; if, however, the natural course of the sap, which is in an upward direction, be altered, they are provided with better nutrition, and the production of new wood in these branches is greater than that of branches further away from the root system of the plant. In this case the primary thickens considerably, sometimes reaching a diameter of 5 centimetres, and at the same time shows great ramification, forming secondary and tertiary branches, which together form a structure which our farmers call a "crinoline".

Pruning.

The object of the art of pruning is to modify the natural manner of development of a plant so as to obtain a greater abundance of fruit, more regularly, and of better quality, than when it is allowed to develop freely. Pruning modifies both the form and the function of the plant.

The practice of pruning has five main objects, viz: —

(1) The production of vigorous trees, strong, healthy, and capable of producing a good crop over a period of several years.

(2) Making the trees a convenient shape for the economic management of the plantation.

(3) Uniform distribution of fruiting.

(4) The production of fruit of good size and quality.

In the coffee tree these objects are pursued by the employment of five different methods of pruning, each with its own special aim. Each of these systems may be conveniently treated according to its necessity for the development of the tree.

Pruning by Formation.

(*Diagram No.* 1.)

Pruning by formation is practised on the main axis of the plant with the object of producing secondary and tertiary shoots. This operation must be begun when the plant is in the nursery and before it has formed its first primary branches. The axis is pruned above the third or fourth pair of leaves, in order that the first secondary shoots shall develop, through the activity of the rudimentary buds which are found in the axils of the leaf. These shoots, on account of the position of the buds from which they sprang, will grow forming an acute angle. In order to separate them at the bottom, and to give a better shape to the plant, a small stake or piece of bamboo, about five to ten centimetres long, is inserted between the two young stems, perpendicularly to them. This is done immediately the young shoots have attained sufficient firmness to hold the stick. When the secondary stems have developed more than five nodes, they are again topped above the fifth node, to increase the activity of the adventitious buds and the formation of tertiary shoots. The growth of these last is more rapid if at the time of pruning the primary branches corresponding to the fifth node are also cut away. The desired symmetry in the shape of the tree depends on the formation only of the tertiary stems on each secondary, so that one should eliminate any other stem springing from an abnormal position, as sometimes occurs. At this stage of its development, the plant will have four tertiary stems, and as pruning by substitution will be performed on all of them, we have called them "shoots for substitution pruning".

The tertiaries, like the secondaries, are pruned above the fifth node, giving rise to eight quarternary stems or fruiting shoots. It is desirable that these shoots should grow as slowly as possible, in order that the whole skeleton of the plant below them shall become strong and develop vigorously. This is achieved by not cutting the primaries which correspond to the node above which the tree has been capped (Fig. 6). The fruiting shoots, whose life, because of pruning by substitution, will not be more than two years, will be pruned as necessary above the fifth node.

Pruning by Restoration.

This system of pruning is practised on primaries which have borne fruit for two successive years. The practice in Costa Rica is to remove these branches completely as soon as they are no longer capable of bearing fruit, and the result is the formation of haphazard branches of every sort, very thick and rising to a considerable height. The tendency of our system is nevertheless to maintain the zone of fruiting of the plant as near as possible to the roots, for the reason that, the further away from the roots the fruit-

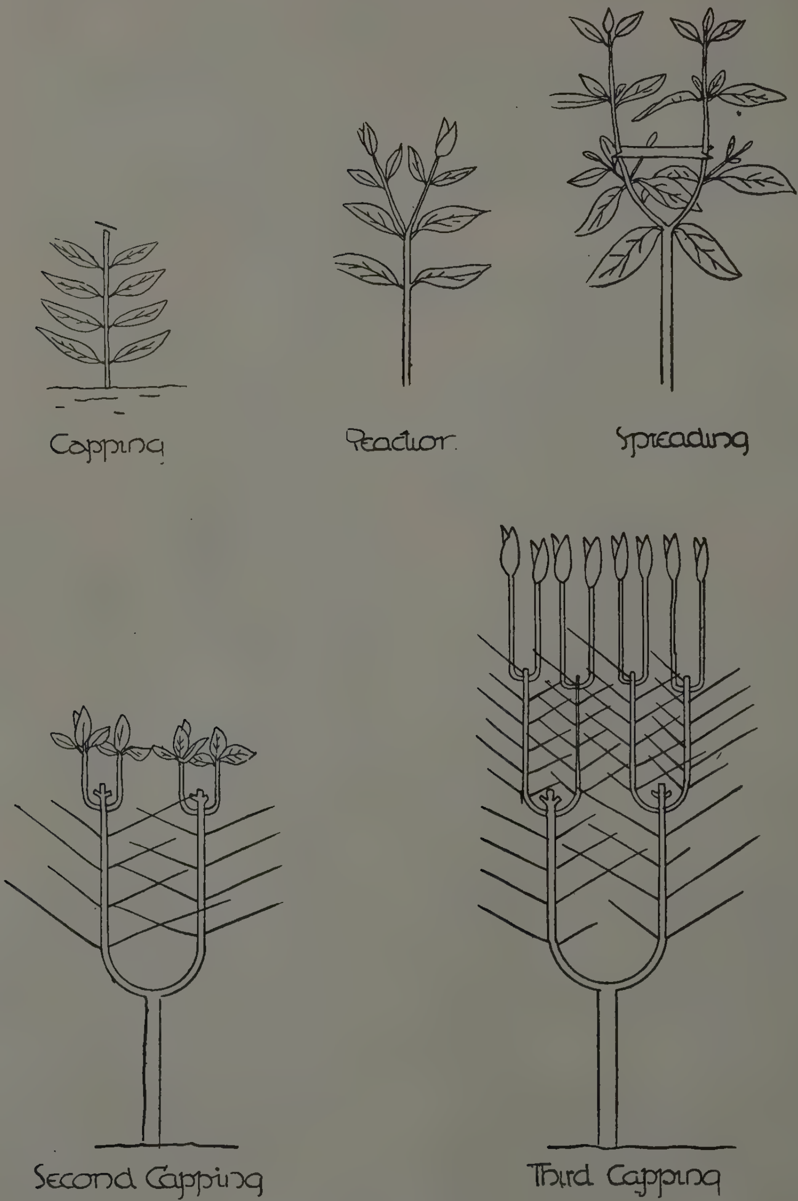


DIAGRAM No. 1

ing branches are, the longer will the primary grow during an active season, and consequently the smaller will be the crop which the branch can produce. The system of pruning by restoration is applied therefore to all the primaries above a height of about fifty centimetres from the ground; that is, the branches are cut, when they show signs of weakening after bearing fruit for two years running, at the first and second node from their junction with the stem. Unless the primary has for some reason or other lost its vitality, this pruning produces the development of secondaries, usually one, sometimes two or more, which, during a season of activity, will lengthen almost as much as a primary, and produce a very heavy crop the following year (Figs. 7 and 8). When this new branch has borne one large or two small crops, it will be restored by the same system, that is to say, it will be cut above the first node from its junction with the primary. It is not always desirable to apply pruning by restoration to all the primaries, as, if these are very numerous, one runs the risk of producing very dense foliage, which may make for an unhealthy state.

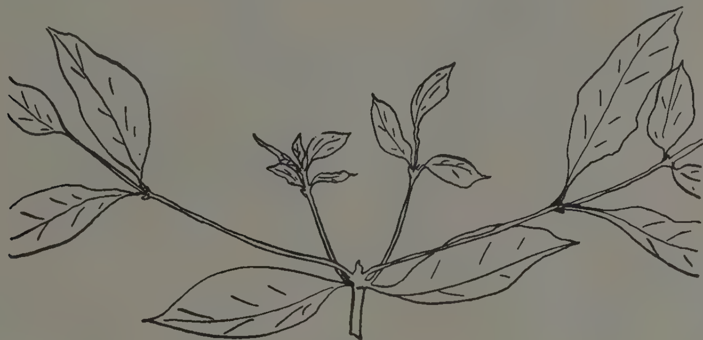
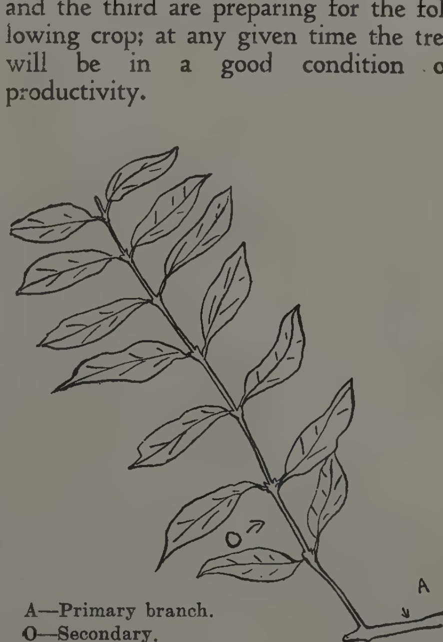


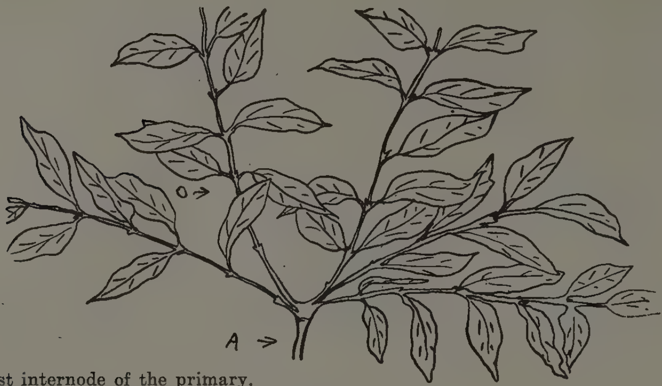
FIG. 6

After three or four years from the commencement of pruning by restoration on a plant, its branches will have become considerably thicker and capable of producing and carrying heavy crops. Since the primaries of a plant do not all appear at the same time, but in succession from below upwards, when the first primaries are restored the second are bearing fruit and the third are preparing for the following crop; at any given time the tree will be in a good condition of productivity.



A—Primary branch.
O—Secondary.

FIG. 7



A—First internode of the primary.
O—Secondary branch.

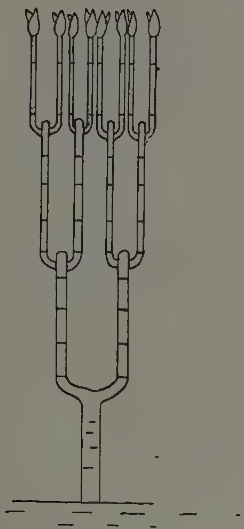
FIG. 8

PRUNING BY SUBSTITUTION.

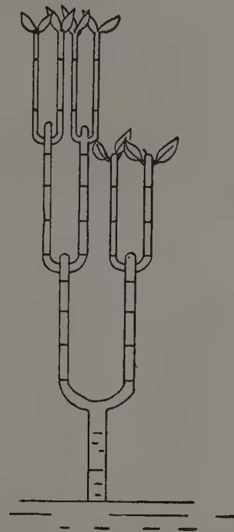
(Diagrams Nos. 2 and 3.)

The skeleton of the tree having been already formed by the method described in the section on pruning by formation, if the tree is left to continue its development freely, the eight quarternary shoots will lengthen indefinitely, each year increasing less than the year before, on account of the greater distance from the root system, and as a result the lower parts of the tree will weaken to a certain extent, these being the parts which are capable of the greatest productivity and which we wish to maintain in as vigorous a state as possible. If these shoots were pruned as they grew longer, the result would be an excessive multiplication which would also tend towards debility in the lower parts and, at the same time, undernourishment in the terminal shoots. To avoid this, the system which we have named "pruning by substitution" should be practised. This consists in pruning, after the first fruiting of the primary branches corresponding to the quarternary shoots, two of the tertiaries above the fourth node, or the one inferior to the fork formed by the two quarternaries (Diagram No. 2). The result is the formation of two new quarternary shoots above the fourth node of the tertiary. This pruning should be carried out, on the Pacific side, at the end of the dry season, and on the Atlantic side when the tree shows least activity. The following year the same operation is performed on the two tertiaries which were not pruned the previous year. The third year from the beginning of this pruning, two of the substitution shoots are cut above the third node, and the fourth year the operation is repeated on the remaining two. This pruning is continued in successive years until the substitution shoots are completely worn out, after which the secondary is pruned above its fourth node, in order to restore the two tertiaries, which, pruned at the fifth node, will serve in subsequent years as substitution shoots (Diagram No. 3). When these latter are worn out, their place will be taken by the branches arising from the tertiaries pruned above the third node.

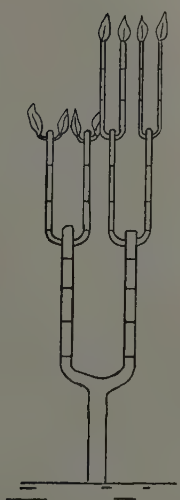
Theoretically, pruning by substitution would keep the tree young for 104 years, but since, on account of the accidental destruction of the adventitious buds, the new shoots do not always appear at the node above which the branch has been pruned, this result is not obtainable in practice.



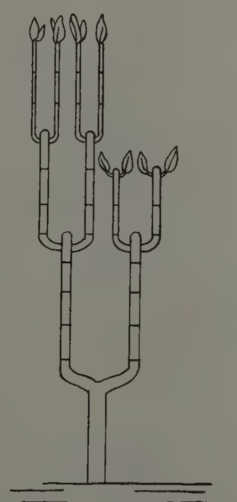
Formed Plant



First Year



Second Year



Third Year

DIAGRAM No. 2

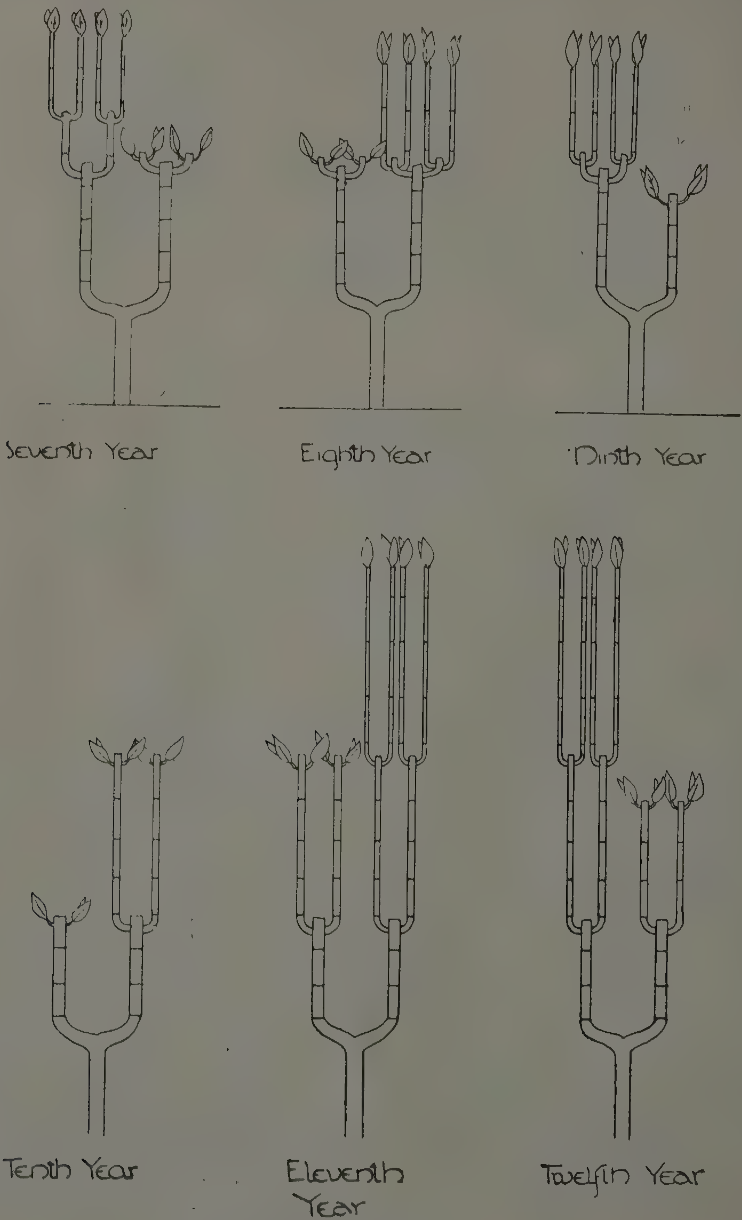

Seventh Year
Eighth Year
Ninth Year
Tenth Year
Eleventh Year
Twelfth Year

DIAGRAM No. 3

Pruning of Suckers and Adventitious Shoots (*Hijos*).

The *hijos* are shoots growing from the nodes of the vertical stems, below the junction of the primary branches. These shoots are the result of the development of adventitious buds, generally produced by excessive defoliation of the tree, either by diseases in which the leaf is the organ affected, as a consequence of a heavy crop when the tree could not produce new wood, or after a prolonged drought accompanied by strong winds. The usual pruning practice of our farmers consists in destroying these shoots, tearing them out from the base so as to avoid the debilitating effect which they might have on the tree. One should remember that these shoots rise from adventitious buds, and that by destroying them one removes the possibility of their developing if it should be necessary for uniformity of results in pruning by substitution. This danger can be avoided by pruning the shoot above the first node from its junction with the stem. If it is surrounded and covered by the foliage of the plant, its development will be arrested; but if pruning by substitution reaches the node from which it springs, the adventitious buds beneath its only pair of primaries come into activity and give rise to two vertical stems, one of which is left to take the place of a quarternary.

The suckers (*mamones*) are those which grow from the main stem below its first bifurcation. Since they are near to the roots, their development is rapid and they should be eliminated, for otherwise they will weaken the whole of the structure above themselves. In a case in which the plant has, for any reason, lost its vigour, the suckers may serve to develop a new and vigorous framework.

Pruning by Elimination.

This class of pruning consists in the elimination of a complete organ which has permanently lost its vigour, or which has for any reason died and constitutes a menace to the health and life of the tree.

The farmer should keep his trees under constant observation to prevent withered stems or branches from remaining any length of time on the plant and endangering the development of luxuriant growth.

General Pruning Practices.

Every stem or branch consists of nodes and internodes; new shoots grow only from the nodes. If when a branch or stem is cut a part of the internode remains, the sap will not rise beyond the node, and all the wood above will die from lack of nutrition. As soon as the material dies, fungi and other saprophytic organisms begin their work of destruction, giving rise to the phenomenon commonly known as decay. The decay extends to the healthy material, and may affect it and endanger the health of the whole plant. It is therefore of the utmost importance that in pruning the cut should be made as near as possible to the node. In this case the cells of the bark continue their work, and rapidly form a covering for the wound, preventing any danger of infection. When the stem which has been cut has a diameter greater than 3 or 4 centimetres, the cut should be painted with oil or tar to exclude all possibility of infection until it is covered by bark.

In pruning primaries and capping tertiaries, it is convenient to use secateurs, as being quicker.

For pruning thick branches, a pruning saw is more efficient and economical than the knife usually employed. If the surface of the cut is large, it is well to use a sharp knife after the saw, in order to leave it completely smooth, which greatly reduces the chances of infection.

Notes on Two Injurious Psyllids and Their Control

By W. VICTOR HARRIS, *M.Sc., Asst. Entomologist, Department of Agriculture, Tanganyika.*

Psyllids are plant-sucking bugs related to the aphids, white-flies and leaf-hoppers. Seen at a distance they are not unlike winged aphids, but close examination shows them to be more like miniature cicadas. The hind legs are well developed, and the insects jump a considerable distance when disturbed, hence the popular name, "jumping plant lice". Two species known to be injurious to economic plants in Tanganyika are dealt with here: *Spanioza erythreae* Del Guercio,* on citrus, and *Phytolyma lata* Wlk., on mvule (*Chlorophora excelsa*).

THE CITRUS PSYLLA.

The foliage of citrus is frequently observed to be pitted, and in more extreme cases crumpled. The effect is unsightly, and in the case of nursery stock and young trees proper development is interfered with. On the under-surface of such leaves will be found numbers of small scale-like insects, the nymphs or immature stages of the citrus psylla. These nymphs are oval, between one and two millimetres long, according to age, yellow in colour with two pink eye-spots. Each is surrounded by a narrow white fringe of wax (Fig. 1). Though sedentary in habit, they possess well-developed legs, which permit them to move about the leaf when disturbed or when congestion compels them to migrate to less populous parts of the leaf. Each individual lies in a shallow pit, which shows convex on the upper surface of the leaf. These pits are caused by the feeding punctures of the nymphs, and increase in size with the bugs. Pitted leaves do not regain their shape after the insect has left.

Curling results when the pits are numerous. From these nymphs emerge the adult winged insects, 3 mm. in length, pale green in colour when newly

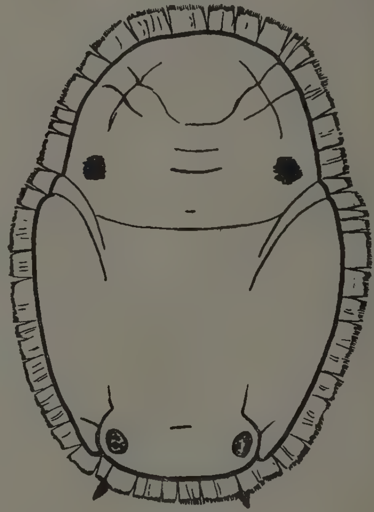


FIG. 1
Citrus Psylla (*Spanioza erythreae*) Nymph

emerged, but darkening later until the head and limbs are a dusky black, the thorax light brown and the abdomen grey (Fig. 2).

FIG. 2
The Citrus Psylla (*Spanioza erythreae*) Adult

* = *Trioza merwei* Pettey (Pettey, 1932; Dept. Agr. S. Africa, *Entom. Memoir* 8).

The psylla deposits its pear-shaped yellow eggs only on succulent young shoots, not on large leaves. These eggs hatch in from five to six days, and the small nymphs seek out a vacant space on the under-side of a leaf in which to settle. A pit develops if the tissues chosen are young enough, and there the nymphs remain and develop unless disturbed. Between two and three weeks are passed in this stage.

The citrus psylla breeds all the year round, but usually is noted only when the plants produce a flush of leaves. In nurseries, particularly where plants are growing under shade and the foliage accordingly remains tender for a longer period, psylla injury may occur at all seasons.

Spanioza erythreae was originally described from Eritrea, from where it occurs right down the east coast of Africa to the Cape. Its natural host plants are members of the Rutaceae, the family to which the cultivated varieties of citrus belong. It is easily spread on infested nursery stock to areas where it does not occur naturally on its wild hosts.

The Mvule Gall Psylla.

The planting up of new areas with the timber tree mvule (*Chlorophora excelsa*) is at present difficult owing to the attack of the gall psylla. This insect causes the new shoots of nursery plants, and young trees in the field, to develop into galls instead of normal foliage (Fig. 3). The lack of sufficient leaf hinders growth, the affected plants are stunted, and frequently die. Galls are also to be found on newly flushed leaves of larger trees, but they are there of little importance.

The mvule psylla resembles the citrus psylla, but is brown in colour, more robustly built, and from three to four millimetres in length. Similarly it lays its eggs only on young tissues, commonly on buds, but also on the under-surface of small leaves, near the midrib, and on the leaf-stalk. After about eight days, the eggs hatch and small pale nymphs emerge. They crawl about seeking a suitable point for attack. The feeding punctures, once the nymph has settled down, stimulate the rapid production of gall tissue, and the bug is soon enclosed in a cell where it is safe from further interruption during its development. The earliest time for signs of gall formation to be noted in the laboratory is ten days after the liberation of adult psyllids.

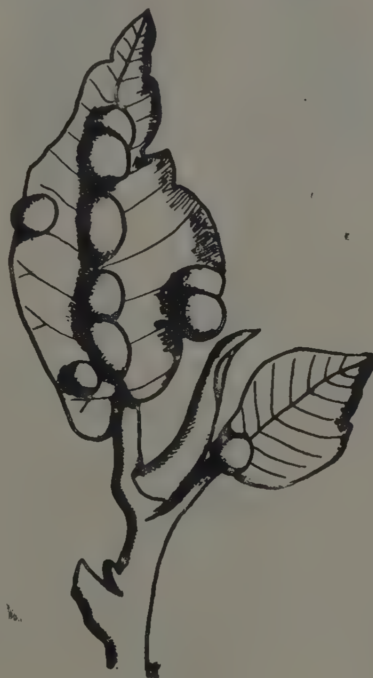


Fig. 3
Psyllid Galls (*Chlorophora excelsa*) on young leaves of Mvule

The nymph is 2.5 mm. long when fully grown. It is squat, pale coloured, with black projecting wing pads, and

black markings on the thorax. The legs are well developed (Fig. 4).

FIG. 4
Mvule Gall Psylla (*Phytolyma lata*) Nymph

When development is complete, the gall splits open and the winged adult psylla emerges. There is usually one nymph in each gall, but sometimes two or three are found together. Large multiple galls are formed by the coalescing of individual galls when the infestation is dense.

The mvule gall psylla is parasitized by at least two species of chalcids, the larger of which is dark metallic green in colour; the smaller black. These wasp-like parasites develop within the psyllid nymph, ultimately causing the death of the host. The adult chalcids then emerge through small holes made in galls. The importance of these parasites is being investigated.

CONTROL.

With both of these pests, spraying is only justified in the case of nursery stock and young trees. For citrus psylla, spraying with oil emulsion at fortnightly intervals, while the flush of young foliage continues, will serve to kill the nymphs while they are young and thin skinned. Two proprietary sprays which have given good results in trials are "Volck" and "Alboleum". According to Van der Merwe (J. Dept. Agr. South Africa, 1923), the eggs of the citrus psylla are resistant to sprays.

With mvule gall psylla, oil emulsion sprays have given promising results on a field scale during 1935. The eggs of this psylla would not appear to be so resistant to sprays as those of the citrus psylla, as spraying at intervals of ten days gave satisfactory results and prevented most of the gall formation.

The following cheap and easily made oil emulsion was used in the field on young mvule:—

Motor car engine oil ...	4 gallons
Oleic acid	$1\frac{1}{2}$ gallons
Caustic soda	2 lb.
Water	100 gallons

The oil and oleic acid are thoroughly mixed together and added slowly to ten gallons of water in which the caustic soda has been dissolved. Constant agitation is essential at this stage. The remainder of the water is added as required. The quantity of the emulsifying agents used is higher than in many formulæ, but thorough emulsification is rendered much easier and subsequent stability of the emulsion is ensured, so that the dilution and application of the spray can be left in the hands of natives.

Groundnuts and Their Cultivation

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Groundnuts form a considerable item in the exports from the Tanganyika Territory, usually taking fifth or sixth place in order of importance. At present, production is mainly confined to native cultivation in the drier central and north-western areas, but it is suggested that were planters more familiar with the crop it would find a place in other parts of the Territory on many of the holdings which commonly grow cotton as a cash crop.

THE PLANT.

The groundnut (monkey-nut, peanut) (*Arachis hypogea* Linn.) belongs to the family Leguminosæ and is a species of the sub-family Papilionaceæ. The origin and history of this plant is lost in antiquity. It is supposed to be a native of Brazil. Slave ships are said to have carried it to the west coast of Africa, from whence it was later introduced to the North American continent and to the East. The groundnut is remarkable in that, after fertilization, the flower stalk elongates and turns down, pushing into the ground, where the pod develops and completes its growth.

VARIETIES.

The varieties of groundnut fall into two main groups:—

(*a*) The "bunch" or erect growing varieties.

(*b*) The "runner" or prostrate creeping varieties.

The main value of the groundnut is in the oil which it contains—about half of the weight of the kernel is oil. In general the runner types yield better and have larger kernels than the bunch varieties, but the latter have three big advantages over the runner in that they contain more oil, they mature earlier, and are easier to harvest because the nuts are all produced close to the root of the plant and can be gathered up with little trouble.

CLASSIFICATION OF VARIETIES.

In Tanganyika we have numerous representatives of the runner and bunch types, and occasionally one comes across the semi-erect type, such as the "Mwitunde" variety grown in Usukuma. This variety cannot really be classed as either a true bunch or runner.

Introductions of varieties which are cultivated successfully in other countries have been made by the Department of Agriculture, and one of these varieties, namely the Virginia Bunch, has proved useful under conditions in the Sukuma areas of the Lake Province.

The following classification of recommended varieties may be found useful:

TABLE I

	GROUP 1 Virginia Bunch (Union)	GROUP 2 Manyema Bunch	GROUP 3 Kalande
Type of growth ..	Bunch	Bunch	Runner
Period of growth	100 days	125 days	150 days
Average yield per acre (under Lake Province conditions) ..	700 lb.	700 lb.	1,000 lb.
Colour of skin of nut	Deep red	Light brown	Pink
Usual number of nuts per pod ..	2–4	2	2
Percentage nuts to pods ..	73%	73%	63%
Percentage of oil which may be expected from nut	49%	49%	44%

Virginia Bunch.—This variety was introduced from South Africa, is drought resistant, and a very useful type for farming with machinery. It has been grown in many parts of Usukuma and Unyamwezi for the past six years, and on the generally worn-out soils of those areas a yield of about 700 lb. of pods per acre has been obtained. The Virginia Bunch variety can often be cropped at ninety days, thus allowing of catch-cropping and a wide range of planting dates, so useful to the farmer in areas of uncertain rainfall. Two disadvantages exhibited by the Virginia Bunch should be mentioned here. These are: (*a*) hardness of shell, making hand shelling of this type a very slow business; (*b*) a tendency to produce second growth should rain fall after a dry spell towards the end of the growing season.

Manyema Bunch.—This useful bunch variety is grown by the natives of Unyamwezi, and was introduced to Ukiriguru from the Kahama district in 1933. Manyema Bunch is a medium early type, is easy to shell, and does not produce re-growth under ordinary conditions.

Kalande is the common name given to the favourite runner variety of Usukuma, and is the kind responsible for the bulk of the Lake Province groundnut crop. It is easy to shell, gives a good yield, and does not produce re-growth. The disadvantages of this and other runner types are difficulty in harvesting and late maturity. If the early rains are poor, little success can be obtained with the Kalande type.

Akola Selection No. 10.—This variety was imported from India in 1933, and is a strain of Spanish Bunch evolved for growing on Indian black soils. It may prove useful here in extending the range of soil types commonly used for groundnut production. Akola Selection No. 10 is similar in habit to Manyema Bunch.

Philippine White.—A variety selected for resistance to rosette disease. The following table, compiled from the Ukiriguru Station 1934 Report, shows the degree of resistance exhibited by this variety in comparison with the types already mentioned.

TABLE II

Variety	Percentage Rosette Infection
Virginia Bunch	25
Akola Selection No. 10.. ..	18
Manyema Bunch	20
Kalande Runner	30
Philippine White Runner ..	8

The three main uses to which the groundnut is put are:—

(1) The sale of kernels for crushing. A ready demand and marketing facilities exist in Tanganyika.

(2) The sale of confectionery groundnuts. These are usually sold in the pod to supply a small and specialized market, in which Tanganyika is not at present a competitor.

(3) The use of the whole crop as a stock feed.

Farmers in Tanganyika who wish to engage in the production of kernels are at present advised to plant the Virginia Bunch variety. The use of the Manyema Bunch and Kalande Runner types under certain conditions should, however, not be lost sight of. For instance, Kalande for early plantings, Manyema for mid-season plantings, Virginia Bunch for main plantings and use after green manure and catch crops. At present, kernels of the above three varieties are purchased for the same price and mixed by buyers.

With large-scale production and separate marketing it should be possible to secure a premium on bunch types which have a higher oil content than the runner type. The latter form the bulk of present-day exports.

Confectionery Groundnuts.

Special varieties, usually those with large pink kernels, are used for the confectionery trade. Such groundnuts, or peanuts, as they are generally termed, are usually hand-picked selected samples, and are exported unshelled from China, Java and Spain. At present a market is said to exist for special types of confectionery peanuts if produced within the Empire and marketed on a small scale, say two to three hundred tons annually. Confectionery samples usually obtain a preference of £1/5/0 per ton over the usual rates for crushing types, and this with the addition of Empire preference should enable planters to make quite a useful side-line out of five to twenty ton lots.

Investigation as to the values of established varieties has indicated that some of them have possibilities for the confectionery trade. So far, rather divergent opinions have been expressed as to the value of these local types, and the matter can only be decided by fairly large trial shipments.

Varieties for Stock Feed.

Farmers who desire to grow groundnuts for stock feed are advised to use the runner types, which produce a fairly heavy growth of haulm and a good yield of nuts. The Kalande common runner type of Usukuma is recommended as suitable for this purpose.

Climatic Requirements.

The climatic requirements of the groundnut may be found in most parts of the huge stretches of this Territory which under natural conditions carry a cover of the Acacia-Commiphora, Acacia grass-savanna, Combretum and Miombo vegetal types. Suitable conditions occur from sea-level to about 4,500 feet, and under rainfall conditions of from 25 to 40 inches. A hot climate, with well defined wet and dry seasons, suits this crop. The amount of rainfall required to produce a crop will depend to a large extent on the variety planted; for instance, at Ukiriguru, in a season when Virginia Bunch types matured on 17 inches of rain, the native Kalande matured on 26 inches. It should be remembered that the groundnut is a drought resister, and gives good yields under quite low rainfall conditions.

Place in the Rotation.

If possible, groundnuts should not be planted on the same land more often than once in every three or four years. Few farmers in Tanganyika have as yet adopted any mixed farming rotations, cotton and other annual crops being looked on rather in the light of catch crops. If a set rotation is desired, the following should serve a mixed farm which produces two or three saleable crops and relies on pen manure or compost for the main fertilizer:—

1st year.—Green crop, e.g. Dolichos bean, Stizolobium, cowpeas, for fodder or compost.

2nd year.—Cotton or tobacco.

3rd year.—Maize or sorghum.

4th year.—Groundnuts.

5th year.—Sweet potatoes.

Soil.

Groundnuts will grow well on practically all soils that are fertile, well drained, and not deficient in lime. Good crops can be raised on heavy soil if the soil is well

cultivated, but harvesting operations are made difficult, and for this reason such land is best avoided. A good sandy loam is the best; lime is essential, and lack of it results in a large proportion of "pops" or empty pods.

In choosing land for groundnuts, the character of crops planted or the rotation practised during previous years should be considered. The groundnut requires a clean soil, free of roots, stones and rubbish, and should, if possible, follow a cleaned crop, such as cotton, maize or tobacco.

Preparation of Land.

A very thorough preparation of the land before planting is essential. In the U.S.A. mellow land is ploughed and then harrowed at least three times until the soil is in very fine condition. Such careful preparation is of course particularly desirable in the case of heavier land. Either flat or ridge planting may be practised; the latter being the method adopted by native cultivators.

Fertilizers.

Opinions differ as to the manner in which groundnuts should be fertilized. In the U.S.A. it is generally recommended that well-rotted pen-manure should be applied to the previous crop in the rotation; a manured maize or cotton crop, followed by groundnuts, unmanured, should be satisfactory.

In India, sheep and cattle are sometimes folded directly on the land, 1,000 head of sheep being used to manure one acre in a night. As regards artificial manures, experimental work in India has shown that 70 lb. per acre of 50 per cent potash is the most profitable fertilizer to use. The potash is broadcast at the time of sowing.

Seed.

Good seed is very important; seed which has been heated or bruised is unlikely to germinate. Expert groundnut-growers in the U.S.A. make a very special point in the correct harvesting and storing of seed groundnuts. Good seed is selected from the best part of the field, and cured in small stacks for at least eight weeks. (A shorter period will suffice in this Territory.) After curing, the pods are picked from the vines and carefully stored. Careful shelling of groundnut seed should be done close to planting time. Most native growers in Tanganyika adopt care in the storage of their seed, which is commonly left in closely woven or dung-smeared grain baskets. In Usukuma, the basket of pods is covered with a layer of grass and then the vessel is closed with a thick layer of cow dung.

Sowing and Planting Distances.

Success or failure of the groundnut crop will largely depend on how it is sown. Two very important factors to be considered in each area are the time of sowing and the spacing to be adopted. The general practice is to plant the crop so that vegetative growth is completed during the rainy season, so that ripening takes place in the early part of the dry season.

The normal type of season experienced in the groundnut areas of Tanganyika giving some six months of variable rainy weather, enables the native cultivator to raise crops of late maturing runner types. These are usually planted some two months after the start of the rains, and are ready to harvest at the beginning of the dry season. In same parts—for example, in Unyamwezi, where early maturing native types exist—planting usually takes place early in December or January and the produce is harvested before the end of the rains, while a main

crop of the runner type is commonly sown in the normal manner at the commencement of the dry season.

It should be remembered that the runner type of groundnut takes about five months to reach maturity, so that an early start is desirable, in order to give the crop about four months of good growing weather. With bunch types, which need about five and a half months to reach maturity, two crops can sometimes be raised off the same land in one season, or catch crops may be taken off before or after the groundnuts. The great value of this type in a risky climate is due to the fact that successive sowings can be made, thus spreading the risk of crop failures due to poor rainfall and other factors which may occur seasonally.

Planting distances will depend on the suitability of soil and climate, the type of tools used in cultivation, and the sort of seed used.

In the U.S.A. wide row spacings are resorted to, in order to enable the maximum amount of inter-row cultivation to be performed. In general, wide row spacings, 32 to 42 inches, are used, but the seed is dropped very closely in the row—3 to 7 inches apart. In the Lake Province, spacings of 24 inches by 6 inches have proved satisfactory for Virginia Bunch, enabling inter-cultivation to proceed comfortably until the crop has flowered. For runner types spacings of 3 feet by 10 inches or 2 feet 6 inches by 1 foot 6 inches are to be recommended.

Method of Planting.

Various methods are adopted for the planting of groundnuts:—

(*a*) Shallow furrows may be opened at the correct distances with a light plough; seed is then dropped by hand and the land lightly harrowed.

(*b*) If ridge cultivation is used, seed may be pushed into the soil at requisite distances.

(*c*) A "knocker" and "dotter" may be used. This unique implement is a home-made device, and comprises two sections of a log, which serve as wheels. Wooden pins are inserted at the required spacing distances between plants, on the circumference of the wheels, in order to make "dots" or holes for planting at each revolution: two shafts are braced in front of the wheels to hold them steady. The "knocker" is a log of wood, about six inches in diameter, which is secured below the shafts in front of the wheels; this log breaks down any clods, and levels off the ground in front of the "dotters". If desired, a single "dotter" may be used; this implement resembles a wheelbarrow without the body, and can be run if required amongst trees and stumps. Seed is dropped into holes made by the "dotter" and covered by the planting gang.

(*d*) Groundnut planting machines and adaptations of maize and cotton planting machines are in general use where groundnuts are farmed on a large scale, and are to be recommended for the planting of anything over fifty acres.

Depth of Sowing.

Seed should be covered to a depth of 1½ to 2 inches on light soil, and 1 to 1½ inches on heavy soil.

Intercultivation.

Correct cultivation of the growing groundnut crop is most important, and should begin as soon as the rows can be seen, and continued until the vines begin to cover most of the ground.

For the first cultivation a light turn-plough can be used to get close to the plants and to throw the earth into the middles; this leaves the young plants on

a ridge from which the grass and weeds can be chopped out at the first hand-hoeing. A little later the second cultivation can be given, using the common tine cultivator, when the earth in the middles is levelled off and brought up close to the plants.

Subsequent cultivations and hand-hoeing will depend on the state of the land, but as soon as the plants begin to peg, that is, to send down their peduncles on which the pods form, great care should be exercised, otherwise the young pod stems may be cut. At this time only the middles should be cultivated in order to work a little loose earth under the plants. If weeds are prevalent hand weeding should be given; most of this will have to be hand pulling of weeds and grass.

The important points are for the grower to see that the soil is kept loose, free of weeds, and that no damage is done to the young pods as they form.

Time to Harvest.

Ripeness in the groundnut crop is indicated by the wilting and yellowing of the leaves, and the dying off of the small leaves in the centre of the plant. In order to judge accurately, a few pods should be dug up and examined. If the kernels are full grown and the inside of the shell has begun to colour, the crop is ready for harvesting. The correct harvesting of bunch varieties is important, as delay in lifting, once the crop is ripe, may result in the germination of the new crop of kernels.

Lifting the Crop.

The groundnut crop may be harvested in many ways. If hand labour is used this operation will become a heavy item of expense. It is advised therefore that in all cases machinery of some sort should be used to harvest the crop. A simple method is to use a light plough to lift the plants; this operation is particularly easy when dealing with bunch types. If possible, the plough should be fitted with a long narrow wing and a small mould-board, in order to cut the tap root and loosen the vines without throwing much earth on them. Potato-diggers of the elevator type, or special attachments to ploughs, may be used to advantage.

No more of the crop should be lifted in a day than can be stacked in a day.

After lifting, the vines should be shaken free of earth by labourers using pitchforks.

If the weather is fine and dry, stacking may start about two hours after lifting.

Under African and Eastern conditions, stacking is rarely adopted owing to the lack of attention paid to fodder conservation and the fact that harvesting is normally carried out in well-defined dry seasons. Most farmers should find it well worth their while to stack in order to save the hay, protect the crop from the possibility of rain damage, and be in a position to be able to pick the pods from the vines as occasion arises.

Stacks are made by setting up poles which have two crosspieces a few inches above the ground. Small poles, about 7 feet in length and 3 to 4 inches in diameter, sharpened at both ends, are favoured; crosspieces are 1½ feet long and nailed at right angles one above the other.

Stakes are set into the ground after the rows have been dug. They should be set into well-dug holes, and the soil firmed round about them; crosspieces are then nailed on from about 10 inches above the ground upwards, allowing about three crosspieces per pole. Fifteen to

thirty stacking poles will be required per acre.

Stacking is best done with a 6- or 8-tine fork. Vines are gathered up on the fork and brought to the stack pole, round which they are placed at a suitable distance with their roots towards the pole. The stack is started by laying a few vines on the crosspieces to form a foundation, after which it is built up by packing the vines around the pole by hand, keeping the groundnuts to the inside. The middle should be kept up and the stack bound every now and then by putting vines round the pole, and when finished the stack should be topped up by a few vines or weeds.

Curing.

The crop should be left in the stack until thoroughly dry. In the U.S.A. stacks will stand as long as a month or six weeks before picking starts.

Picking and Cleaning.

Groundnuts are best picked when the vines are dry and brittle; damp weather causes the vines to be tough and makes it difficult to pick off the pods. Hand-picking is now a thing of the past in the peanut-growing areas of America. In Tanganyika, with cheap labour conditions, picking is possible with hand labour, which should not cost more than one half cent per pound of kernels. For regular large-scale production of, say, over one hundred acres, groundnut picking machines should be used.

Groundnuts are exported in the shelled state from East Africa for the crushing trade. Very few buyers of unshelled nuts exist in this Territory, so that the intending planter will have to purchase one of the many types of shellers, either power or hand driven. A cheap but serviceable machine used in the groundnut-growing areas of India, known as the "Sangali" sheller, costs up to £30 (in India), and is capable of shelling 8 to 15 bags per hour at a cost of Sh. 2/50 to 7/50 per ton of kernels. Small hand shellers are also made and can be purchased for a few pounds. For small-scale production, say up to 10 acres under groundnuts, the "Tom Houston" sheller will be found useful, but once the planter has gained confidence and intends to go in for groundnut farming properly he should consider the purchase of a small power sheller.

A comparison between hand shelling and machine shelling with the "Tom Houston" sheller—a machine costing Sh. 25 only—is given below:—

TABLE III

Groundnut Shelling Costs at Ukiriguru Experiment Station

By Machine ..	Two men can shell 1 ton of groundnuts in 6 days, the winnowing of this amount would take two men 9 days.
By Hand ..	One man 105 days to shell 1 ton.

Thus this cheap Sh. 25 machine although it does not winnow can do the work 3½ times as quickly as by hand.

Marketing.

Exporters of groundnuts in Tanganyika buy the crop on the railway or at the coast. Their main difficulties are the smallness of the crop and the competition for it. The kernels are bagged at the rate of twelve bags to the ton, and exported in as fresh a condition as possible.

Vermin.

In Tanganyika the main pests of groundnuts are vermin, such as pigs, porcupines and spring hares, which cause considerable damage in certain areas.

Control methods advised are poisoning with baits prepared with strychnine or arsenious oxide.

Plant Parasites.

In the groundnut-growing areas of Unyamwezi and Usukuma, a yellow-flowered parasitic weed, *Alectra abyssinica,* is very destructive to groundnuts and other common legumes. Eradication may probably best be effected by trap cropping or continued hand pulling before the parasite can flower.

Plant Diseases.

The most important plant disease of the crop in Tanganyika is undoubtedly rosette disease. Rosette disease is a virus carried by an insect, *Aphis leguminosæ.* The disease is believed to survive from one season to another in diseased plants which are left in the field between seasons.

Plants attacked by rosette disease become stunted. The internodes and the leaf petioles are shortened; the leaflets commonly dwarfed and twisted. The diseased leaves become yellow. When part of the leaf is yellowed and part remains green the typical rosette effect is produced. The work of Storey in Uganda has thrown much light on the factors which affect the control of this disease.

Rosette disease has been controlled by the following methods:—

(*a*) Delayed weeding.

(*b*) Spacing the crop as closely as is compatible with the variety chosen.

(*c*) By the use of rosette resistant varieties.

Use of Groundnuts in Stock Feeding.

Groundnuts and groundnut hay form a nutritious feed for stock, as will be seen from the following figures analysis, taken from Bulletin No. 6 from the University of Florida, Division of Agricultural Extension, and the United States Department of Agriculture.

TABLE IV

	Protein	Carbo-hydrates	Fat
Unshelled Ground-nuts	20·4	16·4	32·2
Kernels	25·8	17·5	44·9
Groundnut Hulls ..	7·3	18·9	2·6
Groundnut Hay ..	11·7	46·9	1·8

The following figures analysis on local samples of groundnut vines have been determined by Mr. French, the Bio-chemist of the Department of Veterinary Services and Animal Husbandry. The vines were collected from native fields, and included a fair proportion of root, while a considerable amount of leaf was lost in handling.

TABLE V

	Mpwapwa Tops	American Figures
Crude Protein ..	7·70	10·60
True Protein ..	6·95	—
Ether Extract ..	1·04	3·42
Nitrogen-Free Extract	49·54	50·05
Crude Fibre ..	31·73	26·85
Total Ash	9·90	9·06
SiO_2	5·63	—
SiO_2-Free Ash ..	4·27	—
CaO	0·75	—
P_2O_5	0·51	—

TABLE VI
Digestible Nutrients per 100 Gm.

Digestible Crude Protein	3·83
,, Ether Extract	0·32
,, Nitrogen-Free Extract	39·16
,, Crude Fibre	14·63
,, Organic Matter	57·94
*Starch Equivalent	48·80
Nutritive Ratio	1:15

*Starch Equivalent if fed unchaffed would be 39·60.

Mouldy groundnut hay should not be fed to stock. Hay is best fed in racks for horses and mules, in order that any sand and dust may sift through.

About three-quarters to one ton of hay is usually obtained per acre.

COSTS.

It is not possible to give actual cost figures in a publication for use throughout this Territory. Up to the present costs have only been taken on experiment stations and seed farms in the Lake Province, where crops have been raised with the aid of simple machinery such as ploughs and inter-row cultivators, drawn by the indigenous zebu cattle.

In general, the following costs will have to be considered by the planter:—

(1) Rent or interest on value of land.

(2) Supervision and overhead charges, including depreciation on implements and machinery.

(3) Fertilizer.

(4) Seed.

(5) Stacking poles and bags.

(6) Costs of ox and man labour used in the following operations:—

(a) Ploughing and preliminary cultivation.

(b) Distribution of manures and sowing seed.

(c) Lifting and stacking.

(d) Picking.

(e) Cost of shelling.

(f) Cost of marketing.

Below will be found a note on groundnut production costs as prepared by Messrs. Rounce and Thornton, of the Ukiriguru Experiment Station:—

Groundnut Production Costs from Mwanza Federation Seed Farm, Mwanza District, Lake Province, Tanganyika Territory: 1932-33 Seasons.

General.—(a) The cost of labour is taken at 4 cents per man hour = 32 cents per full day, whereas actual payment is 25 cents. In practice, 8 hours is not spent on the work, owing to delays in reaching fields, roll-call, rain, etc.

(b) The cost of oxen is taken at 9 cents per day. This includes all maintenance, including growing of fodder, silage and hay, and depreciation on oxen and implements at 25 per cent per annum.

TABLE VII

HAND CULTIVATION OF VIRIGINIA BUNCH GROUNDNUTS

	Cost per Acre
	Sh. cts.
Shelling for seed, by hand ..	1 93
Ridging by hand	11 75
Planting 3 rows per ridge ..	2 40
Weeding	82
Pulling by hand	2 97
Harvesting and bagging	5 12
Shelling by hand machine (½ cent per lb.)	2 41
Expenditure	27 40
Yield per acre unshelled, 733 lb...	
Yield shelled, 483 lb.	
Selling price 6 cents per lb.	
Return	28 98
Net profit per acre	1 58

TABLE VIII

OX CULTIVATION OF VIRGINIA BUNCH GROUNDNUTS

	Cost per Acre
	Sh. cts.
Ploughing	1 25
Ox ridging	59
Shelling for seed, by hand.. ..	1 52
Planting, by hand	2 00
Ox ridging-up	08
Weeding, by hand	2 67
Harvesting, pulling by hand, bagging, etc.	8 45
Shelling by machine (½ cent per lb.)	2 58
Expenditure ..	19 14
Yield per acre unshelled, 783 lb.	
Yield shelled, 516 lb.	
Selling price, 6 cents.	
Return	30 96
Net profit per acre	11 82

TABLE IX

OX CULTIVATION OF NATIVE CREEPING GROUNDNUTS

	Cost per Acre
	Sh. cts.
Shelling for seed	88
Ploughing	1 99
Ridging	61
Planting	2 71
Weeding	6 62
Ox cultivation	70
Lifting by plough, stacking in windrows, pulling and bagging (rainy weather and very heavy soil) ..	18 92
Shelling by hand machine.. ..	2 99
	35 42
Yield per acre unshelled, 1,069 lb. Yield shelled, 598 lb. (low shelling percentage owing to bad rains). Selling price, 6 cents.	
Return	35 88
Net profit per acre	46

It should be noted that the full advantage of Virginia Bunch is clear when the harvesting costs are compared with that of the native type. A variation of Sh. 10 and Sh. 13 will be noted. Probably this high figure was caused partly by the heavy soil, but to a great extent by the creeping habit of the plant.

YIELDS.

Under fairly good conditions it should be possible to raise 1,000 to 1,500 lb. of unshelled nuts to the acre. Yields of 800 to 1,000 lb. unshelled have been obtained on experiment stations and native authority farms under moderately severe conditions in the Lake Province, and such yields should be easy to obtain where the farmer starts with new land in suitable areas.

VALUES.

Values of groundnuts have recovered considerably of late, and with the present (December, 1935) ruling prices of £13-17-6 per ton in London, the crop should pay in situations close to the railways or ports, where it can be cultivated as a side-line with implements, oxen and power on land which would otherwise be lying idle.

CONCLUSION.

The claims of the groundnut as a crop for the farmer in Tanganyika are many, but the following are specially worthy of mention:—

(*a*) Suitability of huge areas of the Territory for the type of agriculture in which the groundnut plays an important role in other parts of the world.

(*b*) An assured and established market for kernels.

(*c*) The possibility of farming the crop almost entirely with machinery, thus reducing the risks attendant on so many other crops in East Africa, which at present depend on large supplies of cheap labour.

Those who are interested in the development of native agriculture in their drier areas will find that the groundnut is one leg of the tripod formed by cotton, millet, and groundnuts; and the prosperity of crop husbandry in the dry areas largely rests on this tripod. Lack of seed supplies, impoverished and eroded soils, and particularly the need for either shelling facilities at markets or the introduction of small hand shellers, must be looked to before output increases. The production of any quantity of groundnuts is almost impossible unless the cultivator has a sheller or shelling facilities, and to this fact one may largely attribute the comparative failure of groundnuts to go ahead at the same pace as cotton in the parts of the Lake Province where land and market facilities should make the cultivation of either crop equally attractive. But in spite of the difficulties, one may be almost certain that this crop will

play an increasingly important part in native and perhaps estate agriculture in the dry areas of East Africa.

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A Test of Green Manure Crops.

In the *Philippine Agriculturist*, Vol. XXIII, pp. 543-48, C. S. Alonso describes an experiment, the objects of which were (*a*) to discover the comparative values of nine green manure crops in the Philippines, (*b*) to determine the quantity of dry matter they produce, (*c*) to analyse them for values of N_2 and P_2O_5 in the different stages of growth and development under field conditions. The species used were *Tephrosia candida, T. noctiflora, Crotalaria juncea, C. usaramoensis, C. anagyroides, Indigofera endecaphylla, Phaseolus aureus, Vigna sinensis, Calopogonium mucunoides.* Most of the information obtained is tabulated under the following heads:—

(1) Number of days from sowing to flowering and to maturing.

(2) The average length of roots and stems and the yield of fresh matter in kilograms per square mile.

(3) Results of turning under green manures to a depth of 30 cm., examined at 14-day intervals.

(4) Relative chemical composition in terms of percentages calculated on oven-dried samples.

(5) Comparative yields of fertilizing materials calculated in grams per square mile of fresh matter.

The records are shown for every month of growth from 2 to 6 inclusive, except for *Vigna sinensis*, which was from 1 to 2½ months. Table 3 shows that within four weeks the green manures turned under had all been eaten by white ants, with the exception of *Calopogonium mucunoides* and *Indigofera endecaphylla*. Further tests indicated that these plants were definitely distasteful to the ants. *Indigofera* has to be buried more deeply than the others or it will sprout and root again. *Crotalaria usaramoensis, C. juncea* and *Tephrosia candida* are high nitrogen yielders. *Calopogonium mucunoides* was a low yielder for 3½ months but the highest at 5 months. *Indigofera endecaphylla* was low in nitrogen throughout. Large quantities of phosphorus were found in all plants at the ages of 4 to 5 months.—*Imp. Bur. of Fruit Prod. Hort. Abstracts*, Vol. V, No. 1, Abs. 139, p. 52, 1935.

The Climate and Weather of East Africa

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In the previous articles of this series descriptions have been given—

(i) of the general circulation of the atmosphere as affecting East African climate and weather;

(ii) of the various climatic types, differentiating between the coastal type, the Lake type, the inland plateau, the highlands, and the Northern Frontier Province conditions;

(iii) of the various types of rain and their pictorial representation on the daily synoptic charts.

The practical planter is concerned with applied meteorolgy; but to apply meteorological data in order to effect a solution of the many problems which tropical agriculture presents to the farmer, a certain acquaintance with the general processes of weather is essential. In the previous articles some attempt has been made to supply information for the practical farmer, tending towards an understanding of the principles which underly the formation of the different climate and weather types.

At this season of the year the question uppermost in the minds of all residents in East Africa, whether they are interested in administration, in agriculture, in industry or in commerce, is: What will the general seasonal conditions bring to the country? In other words, the problem of weather prediction, so far as the seasonal rains are concerned, is paramount.

During the past fifteen months a daily synoptic chart, the mechanism of which has already been explained in Article III of this series, has been drawn up. What are the lessons which this chart has taught us in reference to the problem of forecasting? A period of fifteen months, it is true, is very short when compared with the long series of weather charts available in other countries, but the problem of the rains is so vital to East Africa that it is perhaps pardonable to exhibit a certain amount of impatience to reach a solution, however imperfect this may be. In some quarters, in fact, the question has already been asked: What has the Meteorological Service done? A very incomplete and partial statement of what it has accomplished is that during the six years of existence it has covered an area of one million square miles with a network of controlled observing stations, and now draws a daily picture of the meteorological conditions over the greater part of East and Central Africa!

These daily weather charts have revealed some facts of primary importance to the short period forecasting problem. They will be considered in reference to the three rainfall types already described in previous articles.

CONVECTION RAINS.

These rains occur principally in the afternoon and often continue into late evening. What are popularly referred to as the "grass rains" are almost entirely due to this cause. Whenever the direction of the upper winds, as determined from the observation of pilot balloons, reveals a condition of extreme variability, the winds blowing from different directions at different heights above the ground, it is almost certain that convection rains will occur in the afternoon.

Convection rains only occur when great instability exists in the vertical layers of the atmosphere, and although, at the present time, the relation between instability and the varying wind directions is somewhat obscure, it appears evident that the latter is a precursor, or an accompaniment, of unstable conditions.

For the air to be unstable there must be a marked difference in temperature, in excess of the normal decrease of temperature with height, between the lower layers and the upper layers of the atmosphere. This may be caused by extreme heating of the lower layers or by cooling of the upper layers, the latter either being caused by the incursion of a cold air current in the higher strata of the atmosphere or by night radiation from the upper surfaces of cloud. Varying humidity is shown by the dew-point temperature, and it is found that a dew-point temperature value (reduced to what it should be at 4,000 ft. altitude), if in excess of 60° F. over an extended area, is very likely to aid and abet the formation of local showers when unstable conditions exist.

Such conditions, when revealed by the synoptic chart, only permit of short-period forecasts: that is to say, forecasts for twenty-four hours, more or less, in advance. Such forecasts are, however, of the utmost importance to aviation. It is sometimes possible to forecast, in view of the absence of conditions in the neighbouring territories likely to give rise to general wind currents, whether from the north-east or the south-east, that the regime of instability will continue for several days; but the weather charts are still too incomplete, in so far as they reveal conditions in the neighbouring territories, to inspire confidence in forecasting the persistence of instability for any length of time.

Frontal Rains.

These rains are general and persistent. The so-called "long" and "short" seasonal rains are probably of this type. The daily charts have not yet revealed indubitable indications of these frontal rains.

So far, a general current covering a wide area, whether from the west or the south-east, and even from the north-east, if it exists at all altitudes, has given rise to persistent rain such as was experienced during the early part of this year. The current which appears to have been responsible for the excellent rains which characterized the end of December and persisted through January and February, was a westerly one and extended over the greater part of East Africa during this period.

When one or other of these general currents impinges on an intense convection area, the convection rains appear to be greatly intensified and rain is not confined to the afternoon hours, but continues during the greater part of the day.

When the south-east monsoon current sets in, it is generally observable over the Indian Ocean, well to the south of Madagascar, several days in advance of its arrival on the coast of East Africa and the highlands of Kenya. It should thus permit forecasts several days in advance, provided the information is duly received.

An understanding of these frontal rains is our only hope of forecasting with certainty for periods longer than twenty-four hours. The patient accumulation of data, their scientific and technical interpretation combined with continuity in collection on a pre-arranged programme, will eventually lead to a solution of this all-important problem of practical and applied meteorology.

OROGRAPHIC RAINS.

Whenever the general wind currents are sufficiently strong and sufficiently damp, rain occurs on the slopes of mountains and hills exposed to the direction from which the currents flow. These rains are intense in certain regions, and are clearly indicated on the rainfall charts.

The study of zonal weather, i.e. weather as determined by the special configuration of the surrounding land, is becoming more and more important every month. The slopes of Kilimanjaro, of Kenya, of Elgon, of the Aberdares and of the Usambaras, are all regions of intensive orographical precipitation, but there are others, at present not studied in detail, where a knowledge of the relation between general wind currents and the incidence of rain will be of the utmost assistance both to the forecaster and the planter.

The solution of the problem of local forecasting will be greatly hastened if the planting community themselves will assist, by noting the general wind directions on their rainfall returns and by sending in to the Meteorological Service all records of rainfall, no matter how close their stations may be to others already included in the official monthly records.

Intensive study, in which all interested must help, is our only hope of an early solution to this all-important problem of forecasting, both generally and particularly. The basis on which long-period seasonal forecasting may be approached will form the subject of later articles in this series.

Terracing and the Maintenance of Soil Fertility.

The establishment of terraces, whether Mangum broad base terraces on arable land or narrow base terraces in coffee plantations, will go far to prevent the loss of soil fertilty, but the duties of the farmer do not end there. A certain amount of sheet erosion will occur on poor soil between the terraces and the silt will tend to collect in the ditch on the top side of the terrace bank; during heavy rain some portion of the finer fractions of the soil may even be carried away by the drainage water moving along the ditch. Every observant farmer is familiar with the greater tendency of a poor worked out soil to wash and its decreased power of absorbing the rain compared with a fertile soil in which there is a pronounced crumb structure. The good farmer will not be content with terracing alone but will endeavour to retain or increase the humus content of the soil of arable lands by ploughing in green manures and crop residues, compost or *boma* manure, or by mulching or growing green crops or applying compost to the coffee plantations; by this means the texture of the soil will be improved and increased permeability of the soil to the rain will be secured so that the slight run-off and soil movement between the terraces will be reduced to a negligible minimum.

Export of Lemons.

The Rhodesian Co-operative Fruit Growers' Association, Ltd., Salisbury, have been inquiring as to the possibility of an export of lemons from Kenya. The Association would be glad to handle lemons from this country, together with those grown in Rhodesia.

It is stated that 489 boxes of Rhodesian lemons exported overseas in 1935 average a net return to the grower of approximately Sh. 9 per box, f.o.b. Beira. This is equal to Sh. 3/50 per hundred when the cost of packing material has been deducted.